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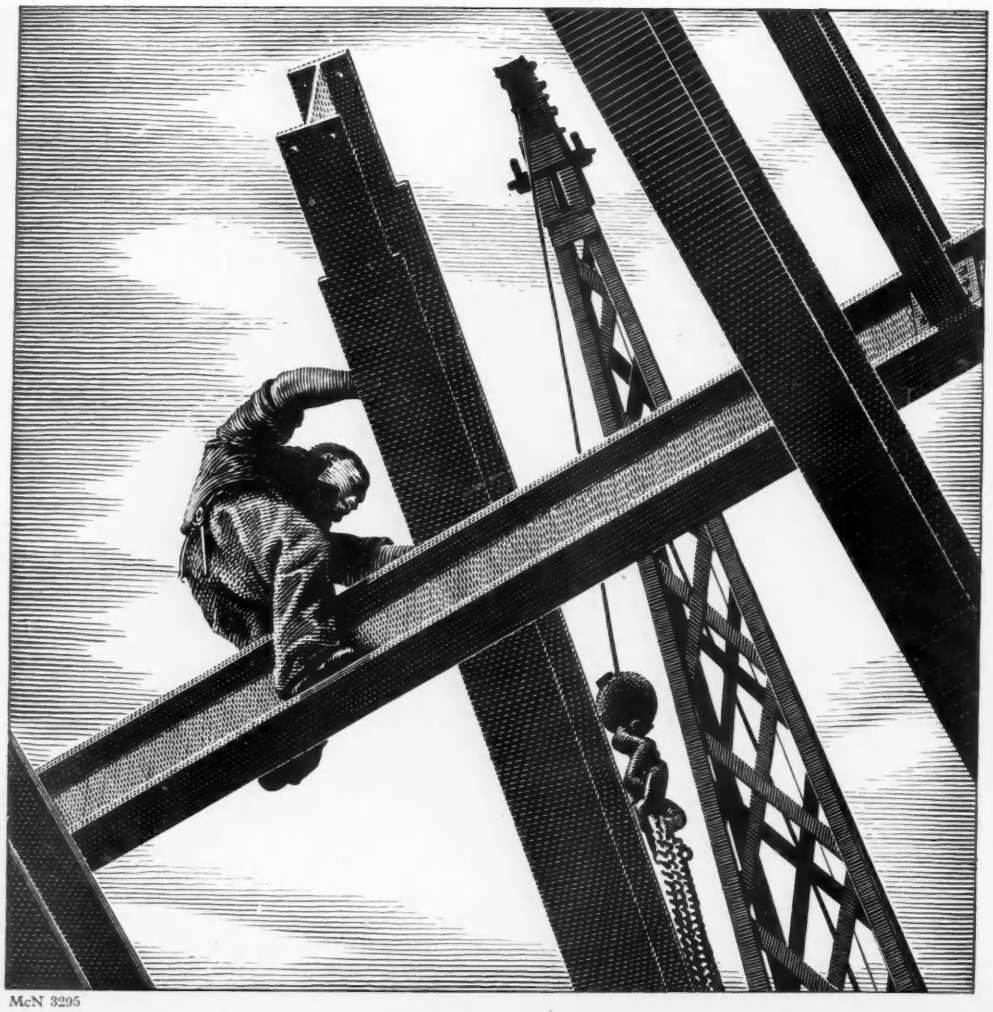

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Centenary of Railway Inspection

ONE hundred years ago, the first Inspecting Officer of Railways was appointed in Great Britain under the Board of Trade, and since that date an unbroken succession of Officers of the Corps of Royal Engineers has formed the Railway Inspections Staff, which is now part of the Ministry of Transport. The Inspecting Officers of Railways are responsible to the Minister of Transport for all technical advice upon railway, tramway and trolley vehicle matters. Their duties consist primarily in the inspection from the safety aspect of new works on railways carrying passenger traffic and of all new tramway and trolley vehicle equipment. They are also responsible for holding inquiries and advising upon all accidents to the public, and to employees in connection with these three transport services. On occasions they act as assessors at Coroners' inquests. In addition to the statutory duties mentioned above, the Inspecting Officers have acted in the past twenty-five years on numerous Departmental and other Committees dealing with such varied subjects as the safety of railway employees, bridge stresses, permanent way and signalling, electrification of railways, automatic train control, wireless in traffic operation, British Standard Specifications, &c. It may fairly be claimed that the cumulative effect of the activities of the inspection staff has been beneficial to the travelling public and employees concerned, and has resulted in increased efficiency and safety in railway, tramway and trolley vehicle operation. Included in the inspectorate since 1900 are four Railway Employment Inspectors, whose duties are chiefly directed to the investigation of accidents to railway servants. During the Great War of 1914–18, such Inspecting Officers as were on the reserve list were called out to take charge of rail transport with the home Army and various commands. Similarly, one officer was released for active service in the present war, while two have joined temporarily. The inspectorate is at present organised in four sections. Besides exercising the Minister's relative functions, powers, and duties regarding the inspection and safety of railways, tramways and trolley vehicle routes, it is now concerned with the maintenance of these undertakings, and with their technical operation and efficiency, their protection and the adequacy of staff, equipment and power, including such matters as the provision of ambulance and casualty evacuation trains.

New Departmental Appointments

THE announcement is made that Lord Beaverbook, Minister of Aircraft Production, has appointed Mr. R. H. Coverley, Controller of Rotol Airscrews, Ltd., as adviser on airscrew and aero-engine production. Mr. Coverley has had twenty years' experience of aero-engine production, design, and development with Rolls-Royce, Ltd. He will continue to act as Controller of Rotol Airscrews, Ltd., which company is now engaged in producing a new airscrew specially designed for the fast fighters of the Royal Air Force. In answer to a question in the House of Commons as to the estimated value of jigs, fixtures, gauges, and small tools required for this year's programme, and the approximate value produced up to date, Mr. Harold Macmillan, the Parliamentary Secretary of the Ministry of Supply, stated that it would not be in the national interest to give this information, but every effort was being made to increase the production of jigs, gauges, and tools. To that end, he continued, the Minister of Supply, Mr. Herbert Morrison, had appointed a director who was dealing specially with those particular problems, and was relating the demand to the supply. That director is Mr. Stanley Harley, who is an experienced man in the industry. With regard to the production of small tools, the Minister, Mr. Macmillan stated, had appointed a Committee under the chairmanship of Lord Riverdale, to advise him as to the steps which were necessary in order to ensure adequate supplies to meet the demands of the various programmes. The Minister of Supply has also appointed Mr. W. T. Wilson, Chief Officer of Supplies of the London County Council, to be Director-General of Equipment and Stores in the Ministry. Mr. Wilson fills the position which was recently vacated by Lord Catto, on taking up his new appointment as Finance Adviser to the Treasury.

Glasgow-Paisley Railway Centenary

SATURDAY, July 13th, marked the hundredth anniversary of the opening of the railway line from Glasgow to Paisley. Although a company had been formed in 1837 for the construction of a railway line from Glasgow to Ayr, it was not until July 13th, 1840, that the portion of the line from Glasgow to Paisley was formally opened. According to the records a company of about 300 persons left Glasgow, in a train composed of nineteen coaches, which was drawn by two locomotives, and arrived at Paisley amid great rejoicings. A large crowd of people assembled in the square in front of the County Buildings and near the railway station, and after the guests had partaken of refreshments they returned to Glasgow by train. Although on that day it was not possible for the train to proceed further than Paisley, work on the Ayr portion of the line was well advanced, and the railway from Paisley to Ayr was officially opened a month later. Actually the Ayr portion of the line as far as Irvine was finished and put into service in August of the previous year. In the year 1841 the railway line to Greenock was completed, and as the junction was at Paisley the importance of that centre was increased, with a corresponding increase in industrial developments. In 1837 a short line between Paisley Abercorn Station and Renfrew had been opened, which is of interest on account of the trains having been horse-drawn. After the opening of the Greenock section of the line, the Renfrew traffic to an embarkation point on the Clyde diminished. The Paisley-Renfrew line and the Paisley-Glasgow lines passed at a later date into the hands of the Glasgow and South-Western, and the Caledonian Railway companies, and for over eighty years the part of the line from Glasgow to Paisley was worked under a joint committee and was known as the Glasgow and Paisley Joint Line. When the regrouping of the main line railways was carried out the lines to Paisley came under the jurisdiction of the London Midland and Scottish Railway Company.

The Registration of Engineers

FOR some time past the members of scientific and technical institutions have been invited to enrol their names on the Central Register, with a view of making the best use of professional engineers in the nation's war effort. On Sunday, July 14th, an Order made by Mr. Ernest Bevin, the Minister of Labour, under the Defence Regulations, came into force, which requires all engineers with certain qualifications to apply by Friday, July 19th (to-day), for registration with the Central Register. Application should be made within five days of the coming into force of the Order to the Ministry of Labour, Central Register, Box III, South-Western District Office, London, S.W.1. The classes of engineers specified in the Order include persons who are normally engaged in the engineering profession in a consultant, technical, or supervisory capacity in design, construction, manufacture, operation, or maintenance, and who have had a regular professional training in practice and in theory as engineers in any of the following branches of the engineering industry :—Aeronautical, automobile, chemical, civil, structural and municipal, electrical, gas, locomotive, and mechanical. Production engineers and engineering scientists are included, and there is no age limit. Members of the Local Defence Volunteers affected must register, but the Order does not apply to engineers already enrolled on the Central Register, either directly or through professional institutions. Those failing to comply with the Order are liable on summary conviction to imprisonment for a term up to three months or to a fine not exceeding £100 or to imprisonment and fine. At the end of June 108,685 persons had voluntarily offered their services in their professional capacity, and of those registered, 95 per cent. are already in employment. The Order which covers Great Britain also applies to aliens, but in their case qualifications for employment will be more rigid and the standard higher than for British subjects.

Proposed New York Dry Dock

THE proposal to construct a dry dock at New York, large enough to accommodate the largest naval or mercantile ships, has been approved by the President of the United States, Mr. Roosevelt, and the Navy Department's recommendation has been transmitted to Congress. According to Mr. Howard S. Cullman, the Vice-Chairman of the Port of New York Authority, the Federal Government and the Port Authority are co-operating in the dry dock scheme, and particulars of the dock have been forwarded to the Secretary of the Navy. The plan is to receive immediate attention as part of the naval construction programme by the Senate and the House Naval Affairs Committee. The Port Authority has also collaborated with private shipbuilding and ship-repairing firms, which also have an interest in the construction and operation of the proposed dry dock. It is planned to build what would be the largest dry dock in the world, having a length of 1100ft., capable of extension to 1200ft., the length of the new Panama Canal locks. By the plan now under consideration, the Federal Government would advance a grant to aid the construction of the entire dry dock scheme, not exceeding in amount 7,000,000 dollars, or about £1,750,000, and the Port of New York Authority would finance the remainder of the cost on a self-liquidating basis. It is pointed out that such a dock, if constructed, would be able to dry-dock either the larger American aircraft carriers or the new 45,000-ton displacement battleships "Iowa" and "New Jersey," which have a designed overall length of 880ft., a beam of 108ft., and a maximum depth of 36ft. At the present time, it is pointed out, the American naval construction programme is considerably hampered by the lack of means to dry-dock these new large battleships which are being constructed at the Brooklyn Naval Yard and Philadelphia Naval Yard. It is felt that the nature of ship-repairing business demands that the operation of such a dry dock should be in private hands. Conferences with representatives of the principal private ship-repairing companies in the New York district have shown that such companies have a keen interest in the proposed dry dock, and would be willing to operate it on the basis of a long-term lease, provided that it is possible to rent the dock on terms which would be reasonably commensurate with the possible revenue from the dry-docking business. Further developments in connection with the scheme will be awaited with interest in this country.

The Opening of the Baghdad Railway

ON Wednesday evening, July 17th, the official opening of the new line from Baghdad to the Bosphorus took place without ceremony, when the first passenger train left Baghdad Station. It had been originally intended to mark the occasion by an opening ceremony at Mosul, to be performed by the Regent, which was, however, cancelled by the Iraq Cabinet on grounds of war-time economy. The Baghdad railway was originally planned by German engineers some fifty years ago. At the beginning of the last war the line had been completed by German firms from Baghdad to Samarra, and during the war it was extended by British engineers as far as Baiji and later to Shargat. Subsequent inspection of that portion of the line between Baiji and Shargat showed the alignment to be unsatisfactory, and the line was pulled up in 1928. The later portion of the railway from Baiji to Tel Kuchuk, a length of about 198 miles, has taken about four years to complete, and has cost £3,250,000. The only tunnel on the main line has a length of 1000ft., and its construction was entrusted to Balfour, Beatty and Co., Ltd., of London, by the Iraq State Railways, who acted as consulting engineers and supervised the work. The contract included not only the tunnel, but the earthworks, bridges, and culverts for about 28 miles of permanent way. This work was started in July, 1938, and was completed in February last. The work included extensive blasting operations, which were successfully carried out. With the present arrangements, when making the journey from the Persian Gulf to Basra it is necessary to change trains at Baghdad, as the line from Baghdad to Basra has a 1-m. gauge, whereas the Baghdad railway itself is standard gauge. From the point of view of Iraq, the completion of the railway marks an important step forward as it permits for the first time railway travel between the three principal cities of Mosul, Baghdad, and Basra.

Vessels (Immobilisation) Order, 1940

THE Admiralty has made an Order requiring vessels on the coasts of the United Kingdom either to be immobilised entirely or else rendered incapable of use if left unattended. On the East and South Coasts, from Berwick to the boundary of Dorset and Devonshire, small passenger vessels and all private and pleasure craft are, wherever possible, to be beached and removed a distance from the water. In the same area all other vessels, whenever they are left unattended, are either to be dismantled or else fitted with a locking device, sufficiently to render the craft incapable of use. This rule also applies to all vessels whatsoever over the remaining part of the coasts of the United Kingdom whenever they are left unattended. Among the appropriate means for rendering the vessels incapable of operation, the following are noted. In the case of steam vessels, the main throttle valve cover plate and spindle or other essential part of the propelling machinery is to be removed from the vessel and stored in a place of safety so as to render the machinery incapable of use. Care should be taken to remove also the spares of any essential part. In the case of motor craft, the distributor arm of the ignition, the fuel injection valve, or other essential part, together with replacement parts, should be removed. In the case of sailing vessels where the masts or mast are fixtures and the sails not portable by a single man, the wheel or tiller or part of the rudder chains or screw gear is recommended to be removed, together with one or more essential parts of the windlass or sail-hoisting winches, if fitted. In other sailing vessels, all oars, rowlocks, rudders, tillers, and sails, other than sails laced to spars, are to be removed. In the case of rowing boats, all oars, rowlocks, rudders, painters, masts, and sails are to be taken away. If this is not done, an adequate and substantial locking device is to be applied to the mechanism, so as to render the vessel incapable of being driven without removing the locking device, and the device locked and the key taken and kept in safe custody.

Automatic Train Control

No. II

(*Continued from page 20, July 12th*)

FROM the survey of the general problems connected with A.T.C., as set out in the first article of this series, the position in Great Britain to-day may now be considered in more detail. To discern clearly the present trend of development it is first of all necessary to recall some systems, quite satisfactory in their practical operation, that have now been abandoned. The two that have been selected for brief mention both had their origin on main line railways having severe suburban traffic conditions in the London area; on one, the former Great Eastern Railway, a service of record intensity with steam was operated in and out of the Liverpool Street terminus, and on the other, the former Great Central Railway, distinctly high speeds were attained. The systems used on these two railways were entirely different in detail, but yielding the same results in principle.

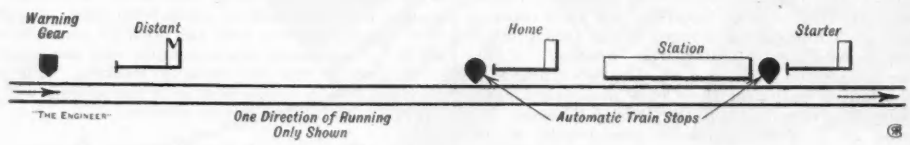


FIG. 8—RELIOSTOP SYSTEM

Fig. 8 illustrates the general lay-out of an interlocking equipped with the Reliostop system, as developed on the Great Central Railway, and

FIG. 9—SIGNAL LOCATION ON SURFACE LINE

FIG. 10—SIGNAL LOCATION IN TUBE

installed between Marylebone and Harrow. In this particular example a home and starting signal is installed. Alongside each of these signals there is a machine mounted at the line side working in conjunction; if either of these absolute stop signals is at danger, a trip device on the locomotive is engaged and a full brake application is made. In the event of an overrun, which would bring this automatic stop into operation, the driver is powerless to cancel it. In addition to this control at the stop signals, through a line-side machine striking a different part of the locomotive equipment an audible warning is given approaching every distant signal and a partial application of the brake is made irrespective of whether the distant signal is "on" or "off." This application, however, could be immediately cancelled by the driver. An important feature of this system is that no electrical equipment whatever is required; the line-side machines are operated by the mechanical signal wires, and the audible cab signal takes the form of a hooter.

The same general principle—an audible warning with a partial and cancellable brake application, approaching an adverse distant, and an irrevocable automatic stop at the home signal—is contained in the S Y X electro-mechanical system as used at one time on the Great Eastern Railway. In this variety of A.T.C., contact between the locomotive and the track equipment was made by means of a ramp installed in the 4ft. way. Differentiation between distant and stop signals and the consequent resulting effect of a partial or full application of the brake was obtained by using ramps of different height; the locomotive plunger was raised higher when passing over a stop signal ramp. Only when the signal, either distant or home, was at clear was any electrical apparatus brought into use; then the current picked up from the energised ramps was used to sound a bell in the cab, and to prevent, by an electro-magnetic control, the application of the brakes which would otherwise be caused by the raising of the plunger.

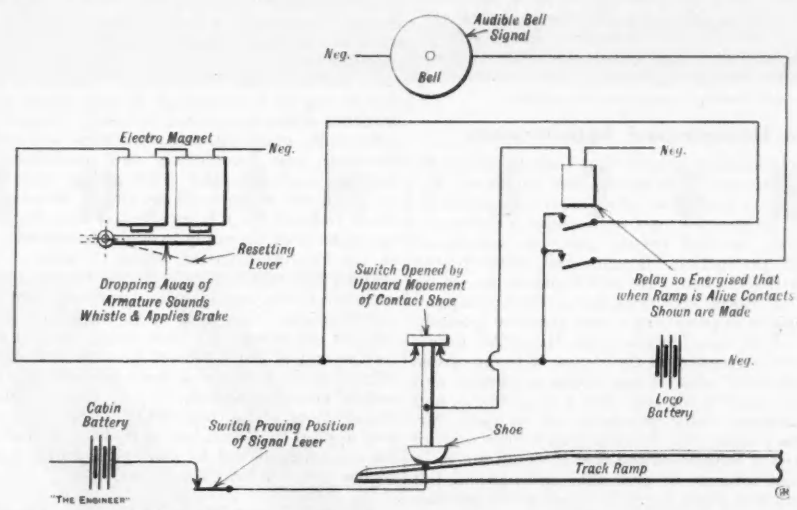


FIG. 11—DIAGRAM OF G.W.R. A.T.C. APPARATUS

It is important to note in both the Reliostop and the S Y X systems that since the brake application at the distant signal is cancellable the train may, through the driver's negligence or lack of judgment, be travelling fast when the automatic stop at the home signal is enforced. The word "fast" is, however, used only in a relative sense. In the Great Eastern suburban area it might be taken to indicate something of the order of 50 m.p.h. From this speed there should be no difficulty in stopping within the 440 yards clearance prescribed by the Railway Clearing House rules. Such a distance might not always suffice for the speeds of 65 to 70 m.p.h., sometimes attained by incoming traffic in the Great Central suburban area, and it would, of course, be totally inadequate for an express passenger train travelling at 90 m.p.h. The installation of the S Y X system on the Ongar branch of the Great Eastern Railway gave entirely satisfactory results; but, like the Great Central system, also referred to, its use has now been discontinued. At the present time there is no instance on the main lines of this country of a train-control system based on the stop signals.

On the other hand, over the entire network of the London Transport electrified lines the system of automatic train control installed is based entirely upon the stop signals. It stands quite apart from the general line of development elsewhere. The circumstances are, of course, exceptionally favourable to such a system; there is general uniformity in running speeds, and in the brake power of the trains. In these conditions it is possible for tube railways to be signalled for a very short headway, and yet provide an absolutely safe margin for overrun, even though an adverse stop signal were passed at full speed. Fig. 9 shows a typical signal location on one of the recent surface extensions of the tube system. The electro-pneumatic train-stop machine is seen exactly abreast of the colour-light signal; the trip arm being lowered. Should the train stop be passed when the arm is in the raised position the trip cock on the train will be struck and an emergency application of the brakes made. Fig. 10 shows a corresponding location in a tube tunnel.

An interesting example of speed control, the first of its kind in this country, has recently been installed in conjunction with the L.P.T.B. standard automatic train-stop system. Owing to the curvature at a particular location where the line descends from the surface to a tube tunnel it was necessary to impose a severe speed restriction, and on account of local conditions it was thought desirable to put a definite check upon the running of trains to ensure that this restriction was correctly observed. To this end special speed-control signals have been installed. These signals remain at danger, irrespective of the state of the road ahead, until the speed of an approaching train has been checked; this checking is done by measuring, with a time-element relay, the time of passage over a length of track-circuit road. For a train running at, or below, the prescribed speed, the signal clears in time for the driver to proceed without any further reduction. If, however, the speed is too high, the signal does not clear and the train is thereby required to stop; in the case of an overrun the train is automatically brought to a stand by the train stop. Excessive speed on the restricted length is positively prevented.

The L.P.T.B. system does not include any form of cab signalling. Only a small proportion of the Board's railway mileage is on the surface, and train running is therefore less likely to be affected by thick weather conditions. On the sections where semaphore signals are used, fog repeaters of a special design are installed to give advance information to drivers, and there is, of course, always the safeguard of the automatic train stop co-acting with the home signal. It was to overcome some of the difficulties of signalling in foggy weather that the Great Western system of A.T.C. was developed, and since detonators were used only at distant signal locations the audible cab signals and associated train-control

equipment was also based, in the first instance, upon the distant signals. The system was tried out as long ago as 1906, on the Henley-on-Thames branch of the G.W.R., audible cab signalling only being provided; but in subsequent installations the control feature has been added, until at the present time all the company's main routes are completely equipped.

Some distance in advance of each distant signal a ramp is fixed in the middle of the 4ft. way; this ramp is electrically connected to the distant signal lever in such a way that when the lever is pulled over to the reverse position the ramp is alive, and when the lever is normal the ramp is dead. The passage of a locomotive over the ramp imparts a vertical movement of 1½in. to a contact shoe suspended from a fitting mounted usually underneath the footplate. This vertical motion takes place every time a distant signal is passed, and it opens an electric switch controlled by the movement of the shoe. Fig. 11 shows, in diagrammatic form, the general arrangement of this apparatus. An accumulator set in the locomotive cab supplies the power for energising the electro-magnet controlling the brake; reference to Fig. 11 will show that the passage over a ramp breaks this circuit, and the de-energising of the electro-magnet causes the brake to be applied and the siren to sound. When the ramp is alive current is picked up by the shoe, and imposed upon the cab circuit in such a way as to counteract the opening of the shoe switch; the current collected from the ramp is also used to ring a bell.

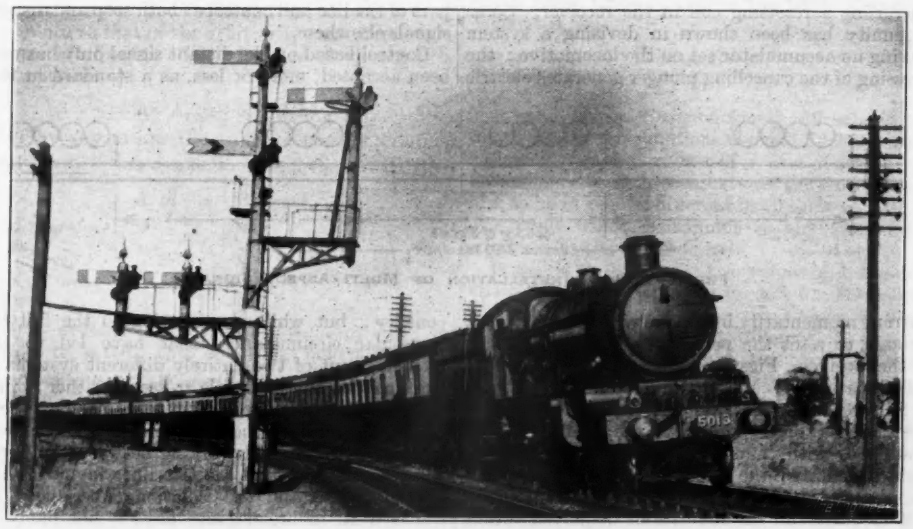


FIG. 12—A.T.C. RAMP IN REAR OF DISTANT SIGNAL

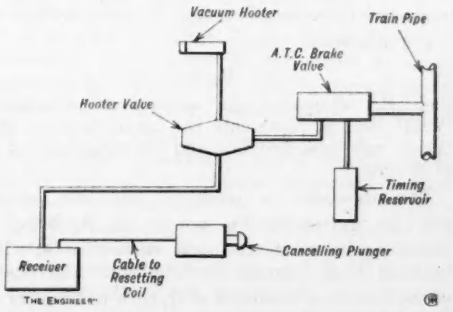


FIG. 13—PRINCIPLE OF HUDD A.T.C. SYSTEM

The audible signals received in the cab corresponding to the "warning" and "clear" are quite dissimilar, a siren blast, and the ring of a bell; to the enginemen, working amid the incessant racket of the footplate, this is a feature of considerable importance. A necessary part of the equipment is a resetting lever, whereby a driver can cancel the automatic brake application. All the parts subject to wear and tear are robustly constructed, and in the case of the ramps particular care is taken to render them as far as possible impervious to damage from anything hanging down from a locomotive or other rolling stock. The gradual extension of the system, considered in relation to the large amount of high-speed running performed in normal times on the Great Western Railway, is in itself a proof of the excellent mechanical performance of the equipment.

As to its effectiveness from the train-control point of view, some interesting data were obtained on a test run made on March 22nd, 1938, to demonstrate the behaviour of the equipment under ordinary service conditions. The test was made on a train of ten passenger coaches, weighing 304 tons, and hauled by a four-cylinder, 4–6–0 locomotive of the well-known "Castle" class, which, together with the tender, weighs 126½ tons. For the purpose of the test a distant signal on a stretch of straight and level road was kept in the caution position, and it was arranged for the enginemen to ignore this signal and to attempt to continue with full steam on. The test train passed over the ramp at 59 m.p.h.; the brakes were automatically applied, and with steam remaining on the whole time the train was brought to a stand in 900 yards from the ramp. The particular ramp is 318 yards ahead of the distant signal, and since the distance from the distant to the home signal is 1032 yards, the stop was made 450 yards short of the home signal—under very exacting conditions. It is not always possible to fix the ramp so far ahead of the distant signal as at the location chosen for this test. In the case of distants mounted on the same mast as a stop signal, as shown in Fig. 12, the ramp is fixed immediately in rear of the signal; thus a driver gets no cab signal, or brake application, until the more important stop signal indication has been observed and acted upon. It would be clearly undesirable to give any cab signal in the event of the stop arm being at danger just when the train was drawing to a dead stand; the fact that the distant arm, relating to signals some distance ahead, was also in the warning position would obviously be of no consequence when a stop there and then was demanded by the indication displayed by the home signal on the same post.

Not only is the entire network of the main lines completely equipped, but, in addition, lines of secondary importance, such as Westbury to Salisbury, and Worcester to Wolverhampton are included, not to mention certain important branch lines. A total of no less than 2852 track miles are concerned, this involving the provision of 2114 ramps. The track equipment is now completed over the whole area, and when the entire scheme is completed a total of 3250 locomotives will be fitted. With the exception of short lengths of track in the London, Birmingham, Bristol, and Cardiff areas, the whole of this extensive mileage is operated on the manual block system with lower quadrant semaphore signals, some of it being single line.

This system provides a valuable additional safeguard in train working, and goes a long way towards eliminating the human element so far as the engine crews are concerned. The loophole, which, as discussed in the first article of this series, is essential if flexibility in traffic operation is not to be seriously impaired, is the feature whereby a driver may cancel the automatic brake application and retain control of the train himself. In Great Britain, however, the likelihood of this feature being misused is so small that its inclusion cannot be considered as a defect in the system as a whole. Looked at from the signalling point of view, however, this particular form of A.T.C. provides no protection against irregular working of the block system by individual signalmen, and there is, indeed, one instance of a collision caused by such an error on a Great Western route fully equipped with A.T.C. Signalmen's errors can only be eliminated by continuous track circuiting; but here, again, the splendid record of immunity from accidents enjoyed by the Great Western Railway is enough to put into the background any suggestion for providing this additional safeguard, particularly if a completeness similar to that of the present A.T.C. system was envisaged and the equipping of some 2800 track miles was involved.

Progress in A.T.C. on the other British main lines has, up to the present, been considerably less rapid. In the case of the L.M.S. and the L.N.E.R. this is probably due, in some measure, to the existence on the lines of certain constituent companies of systems based on dissimilar principles. Reference has already been made to the train-control apparatus used on the Great Eastern and Great Central sections of the L.N.E.R.; on the north-eastern section of the same group a system of cab signalling, without train control, was in service. Naturally the merits of each particular scheme had to be considered in relation to the needs of the new group of railways as a whole, and at the same time a major decision by any one of the groups would scarcely have been made while the whole subject was under detailed investigation by the second Ministry of Transport Committee on A.T.C, appointed in November, 1927. One important aspect of the Committee's report published at the close of 1930 was, to a certain extent, foreshadowed by the decision of the G.W.R. greatly to extend the installation of the ramp system in 1929; the Committee considered that this system was "sufficiently reliable, even under snow and ice conditions, for general adoption."

FIG. 14—INDUCTORS OF HUDD A.T.C. SYSTEM ON L.M.S. LINE

More important, however, than the favourable report upon the ramp-contact shoe method of pick up was the Committee's endorsement of the Great Western principles of cab signalling and train control, which, as previously explained, are based entirely upon the indication displayed by the distant signal. From the point of view of technical accomplishment of the principle, objections have been raised to the use of any arrangement of pick-up involving physical contact between the locomotive and track equipment, and in any case a contact ramp could not be installed on electrified lines using a centre conductor rail. To meet such objections the Hudd system of inductive A.T.C. was developed, and was first tried out in October, 1931, on the Southern Railway. Although using an inductive, as opposed to a contact pick up, the resulting cab signals and train control on passing an adverse distant signal are the same as in the Great Western installations. The apparatus tested at Byfleet on the Southern Railway included control at the home signal also; but this feature has not been adopted in the more recent examples of this form of A.T.C. on the L.M.S., and now in course of installation on the L.N.E.R.

The non-adoption, up to the time of writing, of any modern form of A.T.C. on the Southern Railway is, no doubt, due to the extensive use of long-range colour-light signals in the London area and at other key points on the system. These signals render unnecessary any use of

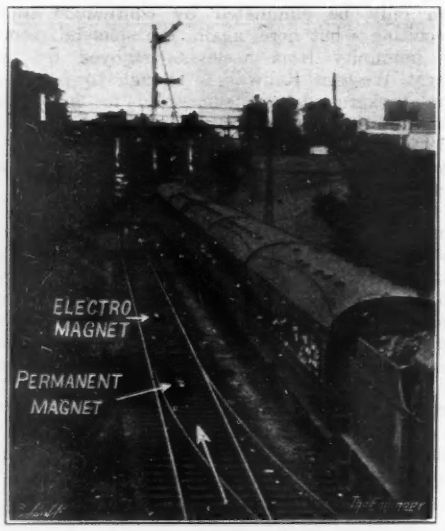


FIG. 15—LOCATION OF INDUCTORS

detonators in fog, and the light beam has a remarkable power of penetration. It may, however, be argued that colour-light signals, though lessening the need for audible cab signals, are not a substitute for train control, in that they do not provide any definite check upon a driver's alertness in emergency. On the other hand, the close spacing of the signals, and the need for keeping a constantly sharp look-out, is much less likely to catch a driver unawares than intermittent signals relating to block sections 2 or 3 miles long encountered in the course of a long non-stop run through manual block territory.

Turning now to a consideration of the Hudd system of A.T.C., its most important difference from the G.W.R. system from the driver's point of view lies in the nature of the all-clear audible signal. Whereas the Great Western gives quite dissimilar sounds, a bell for clear and a siren for danger, in the Hudd both the clear and danger signals are given on the same hooter. The essence of the system when used on locomotives fitted with the vacuum brake is shown in Fig. 13. In association with each distant signal there are two inductors, fixed in the centre of the 4ft. way, and one about 60ft. ahead of the other. The first of these is a permanent magnet, and the second is an electro-magnet energised only when the distant signal lever is reversed and the signal arm has assumed the clear position. Passage over these magnets causes a reaction in the receiver carried on the locomotive; when passing over the permanent magnet a magnetically controlled valve in the receiver opens, and by destroying partially the vacuum maintained in the hooter valve, the hooter begins to sound. If, however, the second magnet is energised its polarity is opposite to that of the permanent magnet, and the passage of the locomotive over it cancels the effect of the first magnet and restores the equipment. The cab signal received is thus a blast on the hooter lasting only during the time the locomotive is travelling the 60ft. between the two magnets.

The hooter valve also controls admission of air to the A.T.C. brake valve, but the timing reservoir in the same circuit enables the balance of pressure to be maintained in the brake valve for a short time—two to three seconds—after the hooter has begun to sound. If the second track inductor is de-energised the effect produced by the first remains unchanged, the hooter continues to sound, and the brakes are applied unless, of course, the driver has in the meantime pressed the cancelling plunger. Cancelling is effected by energising a resetting coil in the receiver. Some ingenuity has been shown in devising a system having no accumulator set on the locomotive; the pressing of the cancelling plunger generates electric current momentarily by magneto action, this being enough to reset the permanent magnet armature in the receiver. Figs. 14 and 15 show actual A.T.C. locations on the L.M.S. Southend line.

So far neither the Hudd nor the Great Western system has been applied to a stretch of line equipped with multi-aspect continuous colour light signalling; the colour light signals extending for the first 10 miles out of Paddington are two-aspect only, and the indications displayed, where two units are mounted together, are the same as in ordinary two-position semaphore signalling. On a section equipped with four-indication colour light signals, as, for example, between York and Darlington, L.N.E.R., there are no such items as distant signals in the ordinary sense of the term. Any of the signals, as shown in Fig. 16, can display either the yellow or the double-yellow indication, and then it is acting as a distant. When the time comes for equipping such lengths of track with A.T.C. it will most likely be found necessary to install inductors or ramps for every signal, and give audible cab signals as at present, according to whether the wayside signal is displaying, on one hand, green, or, on the other, yellow or double yellow. In a system of multi-aspect signalling another problem to be considered concerns the control, if any, to be imposed when a particular wayside signal is displaying "red." A seemingly desirable effect, to be applied in the case of an overrun, would, of course, be an irrevocable emergency brake application. It is, however, very doubtful whether any administration would look with favour upon purely distant signal control on one part of the line and control at both stop and distant signals elsewhere.

Control based on the distant signal only has now been accepted, more or less, as a standard in this country; but while appreciating to the full the particular circumstances that have led to the establishment of two entirely different systems of working out this principle it seems rather a pity that complete standardisation could not have been obtained. It is true that in normal conditions there is not very much interworking between the Great Western Railway and the two lines favouring the Hudd system, and the isolation experienced by the G.W.R. in broad-gauge days is not likely to be felt to any appreciable extent over the question of A.T.C. In an emergency, however, circumstances can well be imagined in which a considerable stud of locomotives might have to be transferred from one railway system to another, and then uniformity in A.T.C. equipment would be invaluable at a time when exceptional conditions would throw great stress upon engine crews.

(To be continued)

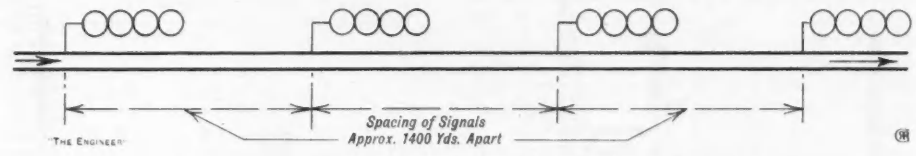


FIG. 16—TYPICAL INSTALLATION OF MULTI-ASPECT SIGNALS

Notes on Methods of Balancing

By K. R. HOPKIRK, M.A. (Cantab.)

No. I

THEORETICAL SOLUTION

IT can be proved, and may here be accepted as an established fact, that in order to balance a cylindrical type rotor, two planes spaced apart axially are necessary and sufficient for the addition of correcting weights. This statement is incorrect only when applied to machines running above the second critical speed, a condition rarely encountered in practice, and of which no account is taken here.

Referring to Fig. 1, the two planes provided for correcting unbalance are represented by P_1 and P_2,

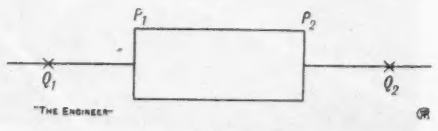


FIG. 1

and the bearings supporting the rotor are represented by Q_1 and Q_2.

An unbalance in plane P_1 is equivalent to a weight W at radius R and the measure of unbalance is W R. This produces a rotating force $\frac{W}{g} R \omega^2$ when rotation takes place, resulting in vibration, *i.e.*, periodic displacement, of both supports Q_1 and Q_2. In general, these displacements will not be in phase with the force producing them. That is, the instant when the maximum displacement of either support in a given direction occurs does not necessarily coincide with the instant when the unbalance force is pointing in that direction.

An unbalance in plane P_2 likewise produces vibrations of both supports. The total vibration on either support is the sum of the vibrations produced by the two unbalances.

For the purposes of calculation any radial direction in the rotor is arbitrarily chosen for reference. The unbalances in P_1 and P_2 can then be represented by vectors $\bar{a}$ and $\bar{b}$ respectively.

If $\bar{a}$ is written

$$\bar{a}=(R_1, \theta_1),$$

then R_1 represents the amount of unbalance $W \times R$, and θ_1 represents the angle between the chosen reference direction and the radial direction of $W \times R$.

The unbalance $\bar{a}$ produces vibration which may be represented by $\bar{A}_1 \bar{a}$ at Q_1, $\bar{A}_1$ being a vector operator of the same nature as $\bar{a}$. Its function is to express the amplitude and phase of the vibration produced at Q_1 by $\bar{a}$ in terms of $\bar{a}$. Thus the length of the vector $\bar{A}_1$ converts the inch-pounds of unbalance into inches of vibration produced, and the angle of $\bar{A}_1$ represents the angle through which the rotor turns in the time interval between the instant when the unbalance is pointing in a given direction and the instant when the maximum displacement of the support Q_1 occurs in that direction.

The total vibration on support Q_1 due to unbalance vectors $\bar{a}$ and $\bar{b}$ can thus be written

$$\bar{u}=\bar{A}_1 \bar{a}+\bar{B}_1 \bar{b},$$

and the total vibration at Q_2 can be written

$$\bar{v}=\bar{A}_2 \bar{a}+\bar{B}_2 \bar{b}.$$

The above two equations most generally represent the connection between the unbalance forces in a rotor and the resulting vibrations indicated at the supports. They apply equally to a rotor running in a balancing machine, or running under service conditions. The constants $\bar{A}_1$ $\bar{B}_1$, &c., depend on the distribution of mass and of elastic properties in the complete system comprising rotor, supports, and indicating instruments, and

on the speed of rotation. For a given system they vary only with the speed of rotation.

In order to balance the rotor correctly, weights represented by the vectors $-\bar{a}$ and $-\bar{b}$ must be added in planes P_1 and P_2, respectively, and then $\bar{u}$ and $\bar{v}$ both become zero together. Moreover, no other disposition of weights but this particular combination will give the desired result of making both $\bar{u}$ and $\bar{v}$ zero.

At the commencement of balancing operations, $\bar{a}$ and $\bar{b}$ are unknown, as are also the transmission constants $\bar{A}_1$, $\bar{B}_1$, &c.

Suppose a weight represented by vector $\bar{c}$ is added in plane P_1. The vector $\bar{c}$ is known since the value of W×R and the direction with reference to that of the arbitrarily chosen reference vector are known. The vibration at Q_1 can now be written

$$\bar{u}=\bar{A}_1(\bar{a}+\bar{c})+\bar{B}_1\bar{b}.$$

If by any means the value of (weight×radius) and the direction can be so chosen that $\bar{u}=0$, then

$$\bar{A}_1(\bar{a}+\bar{c})+\bar{B}_1\bar{b}=0,$$

and therefore

$$\bar{c}=-\left(\bar{a}+\frac{\bar{B}_1}{\bar{A}_1}\bar{b}\right).$$

It is evident that a suitable value of $\bar{c}$ can be found to satisfy this equation, but it will not simultaneously make $\bar{v}=0$.

Similarly, a suitable vector $\bar{d}$ added in plane P_2 can be found to make $\bar{u}=0$, and two other vectors $\bar{e}$ and $\bar{f}$ added in planes P_1 and P_2 respectively will each make $\bar{v}=0$. These vectors are expressed by the four equations:

$$\bar{A}_1(\bar{a}+\bar{c})+\bar{B}_1\bar{b}=0.$$
$$\bar{A}_1\bar{a}+\bar{B}_1(\bar{b}+\bar{d})=0.$$
$$\bar{A}_2(\bar{a}+\bar{e})+\bar{B}_2\bar{b}=0.$$
$$\bar{A}_2\bar{a}+\bar{B}_2(\bar{b}+\bar{f})=0.$$

From these four equations $\bar{A}_1$ $\bar{B}_1$, &c., can be eliminated and $\bar{a}$ and $\bar{b}$ calculated:

$$\bar{a}=\frac{\bar{c}\,\bar{e}(\bar{f}-\bar{d})}{\bar{d}\,\bar{e}-\bar{c}\,\bar{f}}.$$

$$\bar{b}=\frac{\bar{d}\,\bar{f}(\bar{c}-\bar{e})}{\bar{d}\,\bar{e}-\bar{c}\,\bar{f}}.$$

The balance is corrected by adding weights corresponding to vectors $-\bar{a}$ and $-\bar{b}$ in P_1 and P_2 respectively.

The vectors $\bar{c}$, $\bar{d}$, $\bar{e}$, and $\bar{f}$ are calculated from measurements of the vibration taken on the supports Q_1 and Q_2 during trial runs. Considering the vector $\bar{c}$, for instance, it represents the weight placed in plane P_1 that will reduce the vibration at Q_1 to zero. The initial vibration at Q_1 before balancing can therefore be considered as being produced by the vector $-\bar{c}$ in P_1 instead of by $\bar{a}$ and $\bar{b}$ in P_1 and P_2, respectively. In Fig. 2 let this vector $-\bar{c}$ be represented by O A.

If a weight is added in radial direction A B_1 the vibration at Q_1 will now correspond to that produced by unbalance O B_1.

Let the radial direction A B_1 be taken as the reference direction and let the angle by which the unbalance vector O A lags on A B_1 be θ.

The triangle O A B_1 represents two sets of conditions, namely, the relative magnitudes and directions of the unbalance forces in P_1, and the relative magnitudes and phases of the vibrations respectively produced by the unbalance forces at Q_1. Considered as a force triangle, A B_1 only is known. Considered as a vibration triangle, the relative lengths of O A and O B_1 can be measured by means of a suitable instrument. By suitable stroboscopic means, the relative phases of vibrations O A and O B_1 can also be measured.

The measurements of vibration O A are made when running the rotor with no balance weight added. The measurements of vibration O B_1 are made when running after the trial weight has been added at B_1.

First Method.—Assume in the first case that no stroboscopic means of measuring phase of vibration is available. Then in the vibration triangle the lengths of the sides O A and O B_1 are known by measurement. In order to complete the triangle, the length A B_1—that is, the vibration produced by the trial weight alone—must be found.

Let u be the measured amplitude of vibration due to O A, and u_1 that due to O B_1, and let x represent the unknown amplitude A B_1. Then

$$u_1^2=u^2+x^2+2\,u\,x\cos\theta.$$

If the trial weight is now removed from B_1 and added at a position B_2, the angle B_1 A B_2 being α, a further measurement u_2 can be made. This will measure the amplitude of vibration produced by the unbalance force O B_2 and

$$u_2^2=u^2+x^2+2\,u\,x\cos(\theta+\alpha).$$

Similarly, by placing the trial weight at B_3, the angle B_1 A B_3 being β, a measurement u_3 can be made, and

$$u_3^2=u^2+x^2+2\,u\,x\cos(\theta+\beta).$$

From these three equations the angle θ can be calculated thus:

$$\tan\theta=\frac{(u_1^2-u_3^2)(1-\cos\alpha)-(u_1^2-u_2^2)(1-\cos\beta)}{(u_1^2-u_2^2)\sin\beta-(u_1^2-u_3^2)\sin\alpha}.$$

The value of cos θ can be found and substituted in any two of the equations above. Each equation will then give two values of x, one of which will be common to all three equations, the second value of x being in general different in all three equations. The value which is common to any two of the equations is the one required.

It should be noted that two values of θ, 180 deg. apart, satisfy the equation for tan θ. The values of x corresponding to these two values of θ are numerically the same, but different in sign, so that either value of θ gives the correct answer, the change of sign of x compensating for the change of 180 deg. in direction.

In the vibration triangle the vectors A O and A B_1 have lengths respectively u and x, and A O leads on A B_1 by the angle (180 deg.$-\theta$), x, u, and θ being now all known. From the unbalance triangle therefore the value of weight required to reduce the vibration to zero is $\left(\text{trial weight}\times\frac{u}{x}\right)$ placed at a position in advance of the reference direction by an angle (180 deg.$-\theta$).

If measurements of vibration are made at the support Q_2, the four runs that determine the vector $\bar{c}$ yield sufficient information to determine the vector $\bar{e}$. The trial weight should then be transferred to plane P_2 and runs made with it fixed successively in radial positions corresponding to B_1, B_2, and B_3. Measurements made at the supports Q_1 and Q_2 will enable the vectors $\bar{d}$ and $\bar{f}$ to be calculated.

Thus seven runs in all are required.

Second Method.—The use of stroboscopic means to determine the relative phase of the vibrations $\bar{u}$ and $\bar{u}_1$ with respect to one another simplifies the work of finding the vectors $\bar{c}$, $\bar{d}$, $\bar{e}$, and $\bar{f}$. The phase and amplitude of $\bar{u}$ are first measured when running with no weight added. Then, with the weight added at B_1 the phase and amplitude of $\bar{u}_1$ are measured. The angle B_1 O A of Fig. 2 is found by subtracting the phase angle of $\bar{u}$ from the phase angle of $\bar{u}_1$, and the lengths of $\bar{u}$ and $\bar{u}_1$ being known from the measurements, the vibration triangle O A B_1 can be drawn. When this triangle is known the vector $\bar{c}$ can be found as before. The two runs which determine $\bar{c}$ will also determine $\bar{e}$ from measurements made at Q_2. One further run, with the trial weight placed in plane P_2 instead of in plane P_1 gives the measurements at Q_1 and Q_2 necessary to determine $\bar{d}$ and $\bar{f}$.

Thus three runs are required for this method.

The above results were first published, in a modified form, in 1932.*

Third Method.—A complete solution is possible by means of measurements of the relative phases only of the vibrations of the supports, the amplitudes of vibration not being measured. This solution is important because it corresponds to the very old and frequently misused method of balancing by means of pencil markings on the shaft. The angular measurements can alternatively, and probably much more accurately, be made by means of a suitable instrument.

Referring to Fig. 2, let the angles A O $B_1=\phi_1$ and A O $B_2=\phi_2$ be the angular changes of vibration

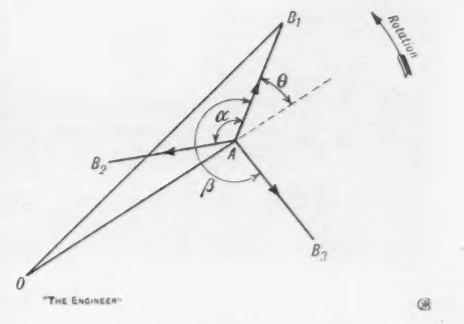


FIG. 2

produced by adding the trial weight at positions B_1 and B_2 successively. As before, let A $B_1=x$ and O A$=u$, then

$$\frac{x}{u}=\frac{\sin\phi_1}{\sin(\theta-\phi_1)}=\frac{\sin\phi_2}{\sin(\theta+\alpha+\phi_2)},$$

therefore

$$\tan\theta=\frac{\sin\phi_1\,.\,\sin(\alpha-\phi_1)+\sin\phi_1\,.\,\sin\phi_2}{\cos\phi_1\sin\phi_2-\sin\phi_1\cos(\alpha-\phi_2)}.$$

This gives two values of θ, 180 deg. apart, either of which gives the correct answer, since a change of 180 deg. in θ reverses the sign of the ratio $\frac{x}{u}$ which is calculated by substituting the value of θ in one of the equations. The ratio $\frac{x}{u}$ is the ratio of trial weight to weight required, the position leading on the reference position 1 by an angle (180 deg.$-\theta$), where θ is chosen to make $\frac{x}{u}$ positive.

Four sets of such measurements are required to determine the four vectors $\bar{c}$, $\bar{d}$, $\bar{e}$, and $\bar{f}$, taken during five trial runs.

(To be continued.)

The Köping Ropeway

BETWEEN the cement mills at Köping and the limestone quarry 42 kiloms. to the south of that place, one of the biggest ropeways ever erected is under course of construction. The town of Köping is situated in the middle of Sweden, about 200 kiloms. due west from Stockholm. The quarry at present produces 475,000 tons of limestone each year, and in the future it will produce up to 750,000 tons a year.

A study was made by the cement mills of the most economical way of transporting the limestone. The following methods were considered:—(1) Railway, (2) canal transport, (3) motor lorry, (4) ropeway.

A railway from the quarry to the cement mill was estimated to cost £257,731, to which would have to be added the cost of rolling stock, &c. The railway would have required a comparatively numerous and expensive staff. The project was therefore dropped because of the big capital investment and high running costs.

The quarry and the cement mill are situated on two lakes, connected by an old canal. It was suggested that five units, each unit consisting of one motor barge towing two lighters, at a speed of 5 knots, could carry the limestone from the quarry to mill. Each unit would have a loading capacity of 600 tons. Three units would always be on the way and two units would be loading and unloading at the terminals. Because of ice troubles in winter the shipping season is short and therefore, if canal transport were adopted, the quarry would be closed in winter time. A large quantity of the stone would therefore have to be stored in the cement mills for the winter. The cost of transport by canal was consequently considered to be unprofitable.

The distance between the quarry and the cement mill by road is 63 kiloms. The maximum wheel load permitted at present is 2500 kilos., and the maximum gradient is 1 : 20. The biggest

* *Comptes Rendus du Congrès International D'Electricité.* Vol. 4. Paris, 1932. "Problèmes se Rattachant à L'Equilibrage Mécanique des Machines Electriques," by K. R. Hopkirk,

motor trucks with the permitted wheel load have a net load of 7 tons. They have hydraulic tipping devices and two drivers are required. Each truck can make four trips a day with a daily capacity of 1585 tons. Fifty-seven trucks would have been needed, working sixteen hours with a double set of drivers. Each truck would have to run annually 144,000 kiloms. The trucks would have had 120 H.P. motors. The standing charges per annum would have been :

	£
Amortisation, 33 per cent.	281
Interest at 3 per cent.	14
Tax	42
Insurance	21
Drivers' wages...	310
Running costs (4 litres petrol per 10 kiloms.) ...	742
Oil and repairs	87
Rubber tyres	186
Total costs per annum per truck	1683

The cost per ton of goods carried would therefore have been very high, namely, 3s. 11d.

The number of trucks required, namely, 57, with 114 drivers apart from reserves and repair staff, rendered the motor truck project impracticable. It was therefore decided to choose a ropeway which was found to give by far the lowest conveying costs. The final figures for the different methods were as follows :—

	Capital investment.	Cost per ton of goods carried (475,000 tons per annum).
Canal transport :	£	s. d.
(Including 1 kilom. ropeway) more than ...	55,150 ...	1 2 (first 10 years) 1 0 (after 15 years)
Motor trucks :		
With Hesselman engines	53,180 ...	3 6
With petrol engines ...	45,835 ...	3 11
Ropeway	208,750 ...	1 0 (first 10 years) 0 6 (subsequently)

LIFTING A TRESTLE MOULD

REINFORCED CONCRETE TRESTLE

THE ROPEWAY

The ropeway will connect the bins at the Forsby crushers to a hopper above the grinder in the mill at Köping. It will carry the limestone crushed to a maximum size of 170 mm. The screened limestone powder will be carried separately from another bin. There was originally some doubt as to where the ropeway could best cross Lake Hjälmaren. Efforts were made to place the ropeway standards as far as possible on islets and rocky shoals. Between these points the bottom mostly consisted of loose muddy clay that would not hold a concrete standard upright. The depth to firm ground was occasionally considerable. The ground to be crossed is in the main very level, and otherwise very suitable for the building of a ropeway. The lay-out of the ropeway was thus fixed in the spring of 1939 as shown in the map.* The profile is especially interesting where the ropeway crosses Hjälmaren sound, and indicates that the longest span will be 540 m., supported by a concrete standard 45 m. high at each end. The navigable channel will lie about 40 m. from one of the standards, and a clearance above the water of 26 m. will be obtained below the buckets, &c., suspended on the sagging cable. At other points on Hjälmaren sound the minimum clearance will be 6 m., which is ample to allow shallow-draught pleasure yachts to pass underneath. The ropeway will also cross another waterway—the Arboga River. For a free clearance of 26 m. the two standards at this crossing, 150 m. apart, will have to be 33 m. high.

The capacity of the ropeway has been fixed at 90 tons an hour, but by employing more buckets and lengthening the working hours, it will be possible to increase the normal carrying capacity from 475,000 to about 750,000 tons per annum. At one time a normal capacity of 60 tons an hour was suggested, but in view of possible future expansion this figure was considered too small.

The leading data of the ropeway are as follows :—

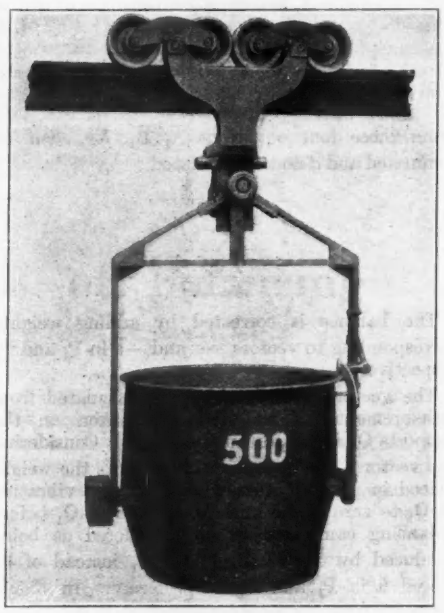
Total length of line	41,630 m.
Carrying capacity	90 tons per hour
Net load per bucket	1200 kilos.
Normal speed	2·5 m. per sec.
Time interval between buckets	48 sec.
Distance between buckets	120 m.
Number of buckets on the ropeway	695
Number of buckets in stations and in reserve	24
Number of standards, ordinary	210
Number of standards, special design	6
Number of tension stations	12
Number of section stations	5
Driving motors	4 at 135 H.P.
Cables and ropes :	
3,100 m. locked coil rail rope	44 mm. dia.
3,100 m. locked coil rail rope	36 mm. dia.
38,000 m. locked coil rail rope	42 mm. dia.
38,000 m. locked coil rail rope	28 mm. dia.
86,000 m. hauling rope, 114 strands ...	25 mm. dia.

The line is on the " bi-cable ropeway " system, with separate rail and hauling ropes. The latter hang directly below the rail ropes. All the sheaves, buckets, wheels, and driving machinery are provided with ball or roller bearings. The distance between the two rail ropes is 3·5 m. from centre to centre. The tensile strength of every wire in the rail ropes is 120 kilos. per square millimetre. The 44 mm. (and 42 mm.) rail ropes consist of an inner, spirally twisted rope of 37 (19) wires, covered first by a layer of 20 (19) wedge-shaped wires, and outside this by a layer of 23 (22) locked wires. The return rail ropes are also of locked coil design, 36 mm. and 28 mm., respectively, in diameter, with a tensile strength of 120 kilos. per square millimetre. The corresponding data for the hauling rope are 114 wires, tensile strength 170 kilos. per square millimetre. The ropeway standards are normally made of reinforced concrete, cast in divided sheet metal moulds on previously prepared foundations. Two of the accompanying engravings illustrate their construction and design.

The ropeway has three driving stations, one at either end and one in the middle, and two intermediate stations without driving motors. These stations are steel structures with frames for asbestos sheet wall panels. In addition to them there are twelve rail rope tension stations, at which the ropes are kept at the proper tension by weight. The ropeway is divided into four sections from 10 kiloms. to 11 kiloms. long, each with its separate hauling rope and motor. Of the four motors, two are situated in the centre station, one at Forsby and one at Köping. The driving gear is identical in all stations, and consists of an electric motor driving, by means of a V-belt and gear wheels, the spur rim of a 3·5 m. two-grooved hauling-rope pulley provided with a device for equalising the wear in the two grooves.

At the full-load capacity of 90 tons an hour, a mass of about 270 tons must, in the longest section, be accelerated to a speed of 2·5 m. per second. Along the full length of the ropeway more than 1000 tons must thus be started simultaneously. To do this smoothly four commutator A.C. motors are installed provided with push-button automatic starter and speed regulation down to a quarter of the normal ropeway speed, and with a bridge coupling for particularly flexible starting. If the capacity of the ropeway is to be increased to 750,000 tons per year, larger motors and more buckets will have to be put in.

The ropeway carriers are four-wheeled and hold the rope by the weight of the buckets. The buckets, as shown herewith, are round, and are slung in hangers pivoted to the carriers just below the hauling rope, thus ensuring a good balance and equal wheel pressure, while there is practically no tilting of the buckets whatever the gradient. Automatic devices have been introduced wherever possible to reduce manual labour to a minimum. The Forsby station is provided with power-operated loading chutes and an adjustable, mechanical, bucket-spacing device. The work of lubrication is also reduced by the employment almost everywhere of ball bearings.



ROPEWAY BUCKET AND CARRIER

The equipment includes a complete signalling and telephone installation allowing free intercommunication by speech or signals between all the terminal and intermediate stations. The linemen will carry portable sets, and can call up the stations from any point on the line. The starting signal is given by means of this equipment. At the terminal stations and at every intermediate station, stop buttons are fitted, which may be used as emergency brakes. The distance between the buckets is regulated by a power-driven adjustable bucket-spacing device at Forsby, where there is also an automatic device for signalling and eventually stopping the conveyor if the buckets should become too crowded owing to faulty spacing.

The following estimate of the costs of the ropeway is mainly based on actual contract prices.

* Up to the moment of going to press the map here referred to has not reached us from Sweden.—ED. THE E.

Interest on capital has been calculated at 3 per cent. Depreciation allowance for buildings, foundations, concrete standards, and permanent steel constructions is taken at 2 per cent., and for cables, machinery, &c., at 10 per cent.:—

	£	£
Standing charges :		
Interest, averaging throughout the amortisation period 3 per cent. on half the initial cost of the plant		2,130
Depreciation :		
2 per cent. on £96,650	1,933	
10 per cent. on £112,120	11,212	
		13,145
Running costs :		
Extra depreciation allowance for wear		3,865
Electric power		1,030
Staff :		
12 station attendants, 2 linemen, 1 foreman		2,420
Sundries		410
		£23,000

or, for a total quantity of 475,000 tons, 1s. per ton.

These costs apply to the first ten-year period. At the end of ten years all the machinery will have been written off, and the corresponding annual amortisating (£11,210) and estimated interest (£1680), or £12,890 in all, will then disappear from the calculation, leaving a subsequent annual cost of £11,115, corresponding to 6d. per ton.

The cost of conveying 750,000 tons a year would be :

First ten-year period...	About 8½d. per ton
Subsequently	About 4½d. per ton

It has thus been possible to reduce the cost of transport to a relatively low level by investing a considerable capital sum, £208,750. The manual labour required for working the plant has been reduced to a minimum. By using all the latest technical improvements and the very best materials, everything has been done to prevent unforeseen interruptions of work, which are also to some extent eliminated by keeping a " buffer " stock of limestone at Köping.

An interesting item in the design of this ropeway is the trestles. The trestles for most ropeways have previously been of steel construction. For the Köping ropeway they are made of reinforced concrete. The trestles are in the form of a single pillar and require only about 1 square yard ground space. Concrete trestles compared with steel trestles show very low maintenance costs as no painting is required. The erection of the concrete trestles is effected by means of equipment moved along the line on a tractor. At one point the ropeway crosses 3 kiloms. of water at Hjälmaren lake. The trestles at this point are constructed in the form of tubes of reinforced concrete. For these trestles special movable steel moulds are used, which are hoisted by means of the reinforcement.

The data in this article of the transporting costs are taken from a report by Mr. N. Danielsen, prepared for the seventeenth International Shipping Conference, and are published with his kind permission. Other technical details are based on information supplied by the manufacturer of the ropeway, A/B Nordströms Linbanor, Stockholm.

American Engineering News

American Railways in 1939

During the last half of 1939, railway business in the United States improved materially, but the constant fluctuations of the past few years make predictions as to 1940 almost useless. This fluctuation is one of the major troubles, since managers cannot see far enough ahead to feel safe in undertaking development or improvement work. Increased taxes and government meddling affect railway business very seriously. Taxes have increased 52 per cent. in a few years, and net earnings only 30 per cent. With 20 new " streamliners " in 1939, the total number of such trains was 82. A notable feature is the striking colour designs adopted, in contrast with the black locomotives and almost black cars which are general on American railways, with few exceptions. While 67 miles of new line were built, no less than 1783 miles were abandoned. Locomotives ordered numbered 471, of which 96 were for export. Of the 375 for home railways, 95 were steam, 32 electric, and 248 internal combustion engines. Passenger cars built numbered 440, and freight cars 62,922, of which 115 and 8483, respectively, were for export. Highway vehicles built for the railways included 1638 motor-trucks, 393 motor buses, and 263 automobiles. About 850,000 tons of new rails were laid. Automatic block signals were installed on 421 miles of single track line, 141 miles of double track and 7 miles of three-track line, making a total of 724 miles of track. An innovation is the " all-coach " train for long distances, the coaches being of modern design, with reclining chairs and other conveniences, and with dining car service. These trains are almost as fast as the extra-fare expresses made up of sleeping cars, while the fares are considerably lower. Safety in operation was at a high level, with only eleven passengers killed in train accidents. With unfavourable financial conditions, there is much need of modernisation of stations, freight yards, &c., and also even more need of making good on deferred maintenance, as well as adopting a higher standard of maintenance.

American Shipbuilding

Examples of present activity in the shipbuilding industry in the United States are four steamers for the Mediterranean, Black Sea, and Eastern service of the American Export Line : the " Explorer," " Express," " Exporter," and " Exchange." They are all 475ft. long, 450ft. between perpendiculars, 66ft. beam, 42ft. deep below shelter deck, with a loaded draught of 27ft., and deadweight, 8775 tons. There are three complete decks and seven cargo holds, with special provision for refrigerated cargo. A cross-compound impulse reaction turbine of 8000 shaft H.P. with double reduction gears to the shaft, drives a four-bladed propeller 18½ft. in diameter at 96 revolutions. Steam at 425 lb. pressure and 740 deg. Fah. exhausting to 28½in. vacuum at 70 deg. is furnished by two single-pass water-tube forced draught boilers at the rate of 85,000 lb. of steam per hour. They are served by a single funnel. There are also three electric turbo-generator sets of 150 kW. At 100 revolutions the shaft H.P. is increased to 8800 H.P. The astern turbine develops 4500 H.P. at 70 revolutions. Both welding and riveting are used in the hull construction. Pilot house quarters and passenger accommodation are provided in a central superstructure, with flush deck forward and aft. The two masts have four cargo booms each, and six king-posts have two booms each. Cargo handling is important in ships for this service and electric double-geared hoists or winches are used. The winch control rooms are well ventilated by fans, for hot climates, and the king-posts serve as ventilators for the holds. The winches handle the steel hatch covers, strongbacks, booms, conveyors and gangways, and haul barges or lighters into position alongside. Air-conditioning is provided for the holds. There is space for 1000 gals. of liquid cargo in deep tanks, 505,000 cubic feet for cotton bales and 29,000 cubic feet for refrigerated cargo.

Viscosity in Flow of Sludges

For the design of pipe lines through which sludge is to flow or to be pumped there is little information on which to base estimates of friction losses, but an investigation at the University of Illinois indicates that viscosity rather than plasticity is a governing factor. Furthermore, with turbulent flow the common hydraulic formulæ for flow of water are not applicable to the flow of sludge. Laminar and turbulent flow of fluids have frictional losses which can be evaluated by certain accepted equations ; but for flow of plastic materials in pipes there are only empirical formulæ and limited records based on experiments. The present investigation has been made in view of the importance of this subject in relation to sewage sludge, slurry from water purification plants, wood pulp sludge, mud used in well drilling, and aqueous suspension of clay and sand in dredging operations. The sludge flowing in the centre of the pipe moves as a solid plug because the shear between the moving layers increases from zero at the centre to a maximum at the pipe wall, and at some distance between the centre and the wall the shear will be equal to the yield value of the sludge. In sewage sludge an increase in temperature lowers the yield value. Bubbles of gas occur in sewage sludge so finely divided as to be unable to rise and escape, as a result of bacterial fermentation, and in this way the density is materially lowered. Investigations into turbulent flow relations of sludge must take into account the density factor. It has been shown that such sludges as are under consideration obey the fundamental formula for a true plastic material. Sludge flowing in a pipe develops a critical velocity as the flow velocity is increased, the flow below this critical point being laminar, while the flow above it is turbulent. In previous investigations the factor of viscosity had not been given much consideration, but apparently this factor is important.

Shasta High-level Curved Bridge

The reservoir formed by the Shasta Dam on the Sacramento River necessitates the reconstruction of a main highway which will be flooded when the water rises. This road will be carried across the reservoir by a steel bridge 1350ft. long, about 14 miles above the dam. At that point the water will be 150ft. deep, so that the tallest piers will be 175ft. high. As the piers will be almost entirely submerged they are made of cellular construction to permit free passage of water, thus eliminating hydrostatic pressure on the pier walls, and adding considerable inertia due to weight of water to resist earthquake forces. All piers are 40ft. long and 8ft. wide at the top. As the road approaches the bridge at an angle and on a gradient of 1 in 17, safe and free movement of traffic is ensured by locating the entire bridge on a curve of 5000ft. The trusses are bent horizontally at two points in each span to conform to this curve, instead of offsetting at the piers, thus reducing the overhang of longitudinal floor girders, while the bending moment in the truss is low at these points. A special alloy steel for the truss spans has 50 per cent. greater tensile strength than ordinary structural steel, while its resistance to corrosion is five times as great. There are five deck truss spans, the centre span of 273ft. flanked at each end by a 252ft. and then a 189ft. span ; these end spans are cantilevered 42ft. beyond the piers to carry a 52ft. girder, so that from the end piers to the abutments the spans are 94ft. The bottom chords of the truss spans are curved. The trusses are 31ft. apart and carry transverse floor girders, on which are nine lines of longitudinal rolled steel beams carrying a deck or floor slab of reinforced concrete, 7½in. thick. This forms a 50ft. roadway for four lanes of traffic, and two 5ft. walks protected by steel railings. To prevent the concrete slab from resisting stress in the trusses it is separated by expansion joints 100ft. apart, which are cut through the longitudinal beams.

British Standards Institution

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria Street, London, S.W.1. The price of each specification is 2s. 3d. post free, unless otherwise stated.

METAL ARC WELDING IN MILD STEEL AS APPLIED TO GENERAL BUILDING CONSTRUCTION

(B.S. 538—1940.)—The revision of this specification has been awaited by industry for some time. It had been known that the main object of preparing this revision was to bring the standard into line with the conditions issued by the London County Council under which welding would be permitted in London. There is accordingly very much which is common in both documents, but the British Standard is somewhat more comprehensive in that it deals in greater detail with the important aspects of workmanship and testing.

TEST CODE FOR STEAM TURBINES

(B.S. 752.)—The British Standard Specification for Steam Turbines (B.S. 132) and the British Standard Test Code for Steam Turbines (B.S. 752) are based on, and for all practical purposes identical with, the corresponding international documents issued by the International Electrotechnical Commission. Since the publication of the Test Code in 1937 international agreement has been reached regarding a supplement to the Code, taking the form of extensive notes on instruments and methods of measurement. These notes have now been incorporated as an appendix to B.S. 752, thereby considerably increasing the usefulness of the Code. A further appendix has also been included, reproduced from B.S. 108, Graphical Symbols, and it shows the internationally agreed symbols for use on diagrams of the lay-out of steam turbine plant. The additional matter runs to forty-five pages, thereby doubling the size of the document.

Copies of the revised British Standard may be had from the British Standards Institution, 28, Victoria Street, London, S.W.1, price 3s. 6d. (3s. 10d. post free).

THE METHOD OF TESTING DUST EXTRACTION PLANT AND THE EMISSION OF SOLIDS FROM CHIMNEYS OF ELECTRIC POWER STATIONS

(B.S. 893—1940.)—As the industrial areas have developed the number of coal-burning installations has increased and this has resulted in the problem of " smoke nuisance " becoming of considerable importance. Some years ago the Electricity Commission set up a committee to inquire fully into the problem in so far as it affected electric power stations, and in the report that was subsequently issued by this committee the view was expressed that before the problem could be adequately tackled it was essential that there should be agreed standards for (*a*) a method of testing the emission of solids from chimneys, (*b*) a method for determining and expressing the size of dust particles. The task of preparing appropriate standards was accordingly referred to the British Standards Institution and B.S. No. 893 has now been issued.

Information on the subject which was available in this and other countries was obtained and examined. Where information was not available an attempt was made to obtain it by arranging for the necessary experimental work to be carried out. Accordingly the fact that a complete answer to the problem has not been obtained is due solely to the complexities of the problem rather than to a lack of their recognition. It is hoped that the accumulated experience resulting from the adoption of the standard methods will provide material that will enable further progress to be made.

The standard is in three essential parts as follows :—

Part 1.—Method for the Determination of the Emission of Solids from a Chimney.

Part 2.—Method for Grading the Dust by Air Elutriation.

Part 3.—Descriptions of various Forms of Sampling Tube which may be Used in Dust Sampling.

A number of diagrams are included in the standard and there is an appendix which deals with the problem of ensuring uniform and uni-directional flow of flue gases, one of the essentials for the reliable sampling of a dust-laden flue gas stream. The standard is one which will be of particular interest to all concerned with fuel combustion.

Copies of this specification may be had from the British Standards Institution, price 5s. (5s. 4d. post free).

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Pencil Portrait No. 25

With this issue we present a Pencil Portrait of Engineer-Vice-Admiral Sir George Preece, K.C.B., Engineer-in-Chief of the Fleet. Sir George was formerly Professor of Marine Engineering at the Royal Naval College, Greenwich, and Fleet Engineer Officer, H.M.S. "Nelson." He was appointed Engineer-in-Chief in succession to Engineer-Vice-Admiral Sir Harold Brown in 1936.

TROOP-CARRYING GLIDERS

THE question is sometimes raised whether those very elementary forms of aircraft known as gliders could not be effectively used as troop-carriers for the invasion of Germany by this country, or *vice versa*. It is raised because such craft are commonly believed to have the merits that they can land in a comparatively small space and are cheap to build. The former quality depends, however, on their being built, as they customarily are, to a very light wing loading, and hence with low air speeds. This advantage would soon disappear, however, should the conditions of operation make very low flying speeds undesirable, as with military objectives in view is not unlikely to be the case. Such gliders would need to be towed over the greater part of their journey by powerful aeroplanes, especially equipped for the purpose. Repeated experiments have shown that this is a not impossible procedure. The gliders can detach themselves at will and carry out the rest of their journey by a long glide, gradually losing height until the earth is reached. It is known that in certain atmospheric conditions, upward vertical currents are met with which can greatly extend the range of such gliders, but these are not conditions which can be counted on as available, and their effect can be ignored as an important factor.

The mechanics of any form of towing is rarely a simple matter, even in the case of an ordinary motor-car and trailer; still less is it so in the case of an aeroplane towing gliders, especially if the latter are designed for a speed much below that of the aeroplane. It is, indeed, easy to envisage conditions in which the resulting motion would be quite unstable. Making the large assumption that these difficulties in design can in practice be overcome, the question which then arises is, What exactly is the military advantage of a troop-carrier having the flying qualities so reached? It may be assumed that the landing speed of the glider can be caused to be such as to require a landing area of less size than a power-driven craft would need, and that instead of seeking an existing aerodrome on which to land, any moderate-sized field would do. But even to select a suitable field requires a certain measure of visibility, and some amount of sunlight or moonlight is needed for this. The glider has not the parachutist's advantage of being operable without undue risk in conditions of complete darkness. This requirement by the glider is a great weakness, as it makes it liable to detection and destruction. It may be safely assumed that the towing aircraft will be detected and attacked many miles before they reach our coast (in the case of attack by Germany). The gliders when released may be expected to lose half a mile to one mile of height for each ten miles they glide through the air, so that their actual point of release must depend upon the position of the desired target and the height of flight, and during this part of their journey they will not be as unnoticed as they think. A feature of glider flight is its silence. Those who in days of peace attended gliding trials were always impressed by this, as they were by the slow rate of descent. Both were really aspects of the craft's ability to glide very slowly, as little as twenty miles an hour; some of them even less. But it does not follow that military gliders would, or could, be so designed, and as their speeds increased, so would the sound. Although engine and airscrew noises are necessarily absent in the case of the glider, a third form of noise—the tearing away of tiny high-speed eddies from the aerodynamic surfaces—would become noticeable, should the conditions of operation make any substantial increase of speed necessary.

From the point of view of defence, whether in Germany or here, the vulnerable features are the easy detection of the air train whilst under tow, and the degree of impossibility of operating in complete darkness during the latter part of the journey, when the tow rope has been dropped and a landing has to be made. As such craft are slow in movement, and have little fighting manœuvrability, they are very easily destroyed from the air once they are seen. On the whole, therefore, there would seem to be little to be gained by their employment. The ordinary troop-carrying aircraft are far more efficient once a suitable landing place can be made available, and prior parachute landings aiming at the commandeering of such aerodromes and making them safe for the larger craft, would seem to be the more likely procedure. Hence, since we do not anticipate any serious difficulty in defeating both of the latter, should they come, it is hardly likely that the glider can add to any danger there might be from such operations.

The Aluminium Scrap Plan

THE appeal of Lord Beaverbrook to the public to give up its aluminium pots and pans to the Government for use in the manufacture of aeroplanes has attracted more attention than most appeals of a similar nature for other materials. Scarcely had it been published, than letters appeared in the daily Press from members of the scrap metal trade stating that they had at their yards large quantities of aluminium scrap which they had been unable to sell; whilst, on the other hand, members of the public wrote demanding that the stocks of new aluminium hardware in the hands of retailers should be commandeered. Whilst these discussions were proceeding in the Press, the Women's Voluntary Services, under the leadership of the Marchioness of Reading, were busily at work arranging collections, and so far as reports go, there are indications that a tremendous amount of this material has been contributed. It will be some time before the actual tonnage is known, but it is probable that it will amount to thousands of tons, since the collection has been nation-wide in every sense of the word and has included the most remote villages and the largest cities. At the same time it is wise to consider how far the complaints and criticisms of members of the scrap trade are justified. Anything which is likely to shake public confidence in the necessity for a Government appeal should be considered, since there will probably come a time in this country when appeals of an imperative character will be made, the success of which will depend upon the voluntary efforts of the population.

The problem of aluminium supplies, like many others, arises from the defection of France, from which we received a great proportion of our supplies of bauxite, the ore from which aluminium is manufactured. In the eight months preceding the war we imported 231,443 tons of bauxite, and in the corresponding periods of 1938 and 1937 170,346 tons and 144,459 tons respectively. Of this quantity, during the whole of 1938 we took from France 187,962 tons, out of a production of 380,000 tons. This, however, would appear to be below the average output, since in 1936 the French produced 638,250 tons and in 1937 677,300 tons. The world's output of bauxite was highest in 1938, so far as statistics are available, and amounted to 3,950,000 tons. Of this total France and Italy between them contributed 1,057,691 tons. Other important producers are the United States, British and Dutch Guiana, Jugoslavia, Russia, and Hungary. It will be seen therefore that the entry of Italy into the war and the collapse of France greatly altered the situation, inasmuch as we are now compelled to draw our supplies from more distant sources. In Great Britain the normal collection of scrap metal has proceeded since the war, and accumulations of aluminium scrap have been built up in the yards of most metal dealers. Roughly speaking, this scrap is in the form of cast or rolled metal. Rolled aluminium is principally used in the hardware industry and as scrap fetches a higher price than cast metal. The dealers, however, have for some months been in the position of having paid a higher price for their stocks than they are able to obtain, as Government specifications, particularly for aeroplane construction, call for very high standards and a quality of metal suitable for extrusion. It is difficult and expensive to refine cast aluminium scrap, but it can be blended with rolled scrap or pure metal to improve the quality. In the case of rolled aluminium scrap from which pots and pans are made the metal is about 98 purity and would require less attention than cast scrap from the refiners whose business it is to produce a material in a form suitable for use by the aircraft industry.

The figures which have been given above show that if there is no scarcity of aluminium in this country at the moment, there is the danger of a stringency developing in the not distant future, and probably the best answer to the criticisms which have been heard of Lord Beaverbrook's scheme is that he has shown prevision in meeting a possible aluminium famine before it was upon us. Whether the scheme is altogether fair to other sections of the community is another matter. The scheme for collecting iron and steel scrap took into account the normal trade channels. Lord Beaverbrook's scheme would appear to have ignored the scrap dealers, who have had anything but a rosy time during the war, and to have relied upon the patriotism of the public to give the scrap to centres from which it can be collected by Government agents. Possibly a way may be found to incorporate the scrap dealers in the scheme, and if this is done there can be nothing but praise for a prompt and decisive action.

Pencil Portrait No. 25

ENG.-VICE-ADMIRAL SIR GEORGE PREECE, K.C.B.

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Literature

The Early Days of the Power Station Industry. By R. H. PARSONS. The University Press, Cambridge. 1940. Price 15s.

ALTHOUGH the plant employed for generating electricity in bygone days was inefficient and troublesome, it represented the work of many able engineers who had little beyond trial and error to guide them. But with all their faults many of the early power stations were spectacular, in contrast with the turbine stations of to-day. With their massive open type slow-speed engine and in some cases rope or belt drives, they gave the impression that considerable outputs were being developed. The introduction of the Willans and Belliss enclosed high-speed engines did much to destroy this outward appearance of power, but it was the high-speed turbine that made units of large capacity small and gave large stations a relatively unimportant appearance. There were in the pioneer days single, two, and three-phase systems and D.C. and high-tension D.C. systems. There were also many frequencies. Almost every engineer who set out to design an electric supply system seemed to strive to do something different from what had been done in a neighbouring area. Each undertaking was a self-contained unit, designed without regard to subsequent standardisation.

Prior to the issue of this informative volume no one appears to have deemed it desirable that an account of the work done in the early period of the industry should be prepared. The research work involved probably caused many engineering writers to leave the job alone. Here, however, we have at last a volume written by a competent authority giving accounts of stations that existed in the dim and distant past and explaining the difficulties that were experienced by engineers in charge of them.

The book starts with a chapter on "The Beginning of the Power Station Industry," in which descriptions are to be found of the lighting of the Thames Embankment and Holborn Viaduct, &c., together with accounts of various early private installations in factories and elsewhere. The Brighton undertaking is here included because it has had continuous existence since February, 1882, until the present time. With this undertaking the name of Mr. Arthur Wright is, of course, associated, and his work, notably in connection with metering, is described.

On the Grosvenor Gallery and Deptford stations, which are considered in Chapter II, more has probably been written than upon other stations, for it is common knowledge that under the genius of the late S. Z. de Ferranti the construction of these stations, and particularly the Deptford station, laid the foundation of the present system of generation and transmission. Almost everything that could happen to disturb the continuity of supply occurred at Deptford, and there is no doubt that the continued failures and disappointments must have been a great strain on this brilliant pioneer. Yet it is known now that Ferranti's instincts were right. In proof of this there stands to-day on the site he chose at Deptford a plant of more than 300,000 kW capacity, the lineal descendant of the station he founded in the 'eighties of the last century. The original station was not only a centre of electrical generation, but also an electrical factory in which the manufacture of two 10,000-kW alternators was put in hand, but never completed.

The pioneer work of Mr. J. E. H. Gordon is considered in another section of the book. Assisted by Mr. Frank Bailey, he constructed a power-house to serve the Paddington terminus of the Great Western Railway and the neighbouring property of the company. Two-phase alternators were employed and a special feature of the system was that the two phases were kept entirely separate, each phase supplying current to a separate circuit independent of the other phase. Like certain other early power stations, noise and vibration nuisance landed the Great Western Railway Company into litigation, but all the satisfaction obtained by the plaintiffs was to be allowed their costs. The early alternators appear to have given a great deal of trouble, mainly, it seems, because the armature coils were originally wound on solid cores of boiler plate. Put into service in April, 1886, the station continued to run until 1907, when it was superseded by a new station erected at Park Royal.

In the early days of the power station industry the employment of batteries of accumulators by means of which a constant supply of electricity could be maintained in the event of temporary breakdown of the generating plant was widely advocated. The system also had the advantage of permitting machines to be shut down during the hours of light load. Moreover, by placing the batteries in sub-stations near the centre of the greatest demand a saving could be effected in the cost of cables, as the mains between the power station and sub-stations need then be no greater than that required to carry a small and uniform charging current.

Several high-tension battery systems are described, but some of them do not seem to have been very successful. In some cases, as at Colchester, the batteries were charged in series and discharged in parallel, thus further reducing the cost of mains by reason of the higher voltage of the charging current. The Colchester system was put into operation in 1884, but in 1886 the whole plant was sold piecemeal under the hammer. There was no further supply of electricity in the town for more than twelve years. Other old high-tension D.C. supplies described by the author are those of the Cadogan Electric Lighting Company, the Chelsea Electricity Supply Company, the Oxford Electric Company, and the Wolverhampton Municipality, the last three reducing the voltage to the network by means of motor generators.

While notable examples of early electrical enterprise were given by a few provincial towns, London was the principal centre of electrical development. "Some of the early London Supply Companies" therefore forms the title of a lengthy chapter dealing with the Metropolitan Electric Supply Company, the Kensington Court Electric Light Company, the Kensington and Knightsbridge Company, the Notting Hill Electric Lighting Company, the Westminster Electric Supply Corporation, the St. James' and Pall Mall Electric Lighting Company, the Charing Cross Electric Supply Company, the Brompton and Kensington Electric Supply Company, the City of London Electric Lighting Company, and the County of London Electric Lighting Company.

Of the generating stations associated with these concerns, that of the City of London Company was one of the more important. As distinguished from the pioneer plant, the present Bankside station (which in its original form was one of the show stations of London) dates back to 1892, when a fine new engine-room and boiler-house were erected independently of the older buildings. The engine-room started work in 1893 with two 200-kW Brush rope-driven alternators, two 400-kW A.C. direct-coupled sets of the same make, and two 350-kW Willans engines, each driving a pair of B.T.H. alternators from the ends of the crankshaft. The second alternator was coupled by a clutch as half load was reached. As in practically all reciprocating engine stations, turbines were installed in due course. One of the troubles that were met with at Bankside was that of maintaining the steam pressure at times of dull or foggy weather. The station was liable to sudden and unexpected peak loads caused by consumers switching on lights when fog or dullness occurred, and low voltage was often experienced.

A story Mr. Parsons tells about the Bankside station concerns a boy who was playing near the suction sump of the circulating pumps and fell in. Fortunately the accident was seen by a workman, who gave alarm, and the pump was instantly stopped. Meanwhile the boy had disappeared into the 36in. suction pipe, which terminated in a sealed screen chamber 150ft. distant, the pipe making a double bend on the way. The chamber was under a vacuum of 20in. of mercury, but an air cock was opened to release the vacuum and the cover lifted by means of a screw and hand wheel with the object of recovering the boy's body. It was twenty minutes after the accident before the cover could be partially raised, when the boy was heard to call out loudly, and he firmly grasped the hand that was extended into the chamber. He was found to be clinging to the screen with his head well out of the water and was apparently none the worse for his experience. It is probable, Mr. Parsons says, that the boy's lungs, being full of air under normal pressure, were to some extent protected against the entry of water under reduced pressure, but whatever may be the explanation of his escape, the facts are remarkable.

The final sections of the volume are devoted to Early Municipal Power Stations, The Battle of the Systems, Gas Engines in Power Stations, Reciprocating Engines in Central Stations, the Introduction of the Steam Turbine and Legislation Affecting the Electrical Industry. There is also an appendix on The Heat Consumption of Power Stations and another on The Effect of Load Factor and Output on Efficiency.

Of the final chapters that on "The Battle of the Systems" is one of the most interesting, for it shows, as is well known, that in the early days there was much diversity of opinion regarding the relative merits of A.C. and D.C. The difficulties that existed at the time of running alternators in parallel was a point often stressed by the advocates of D.C., who also pointed to the advantages of accumulators. The question of running alternators in parallel formed the subject of many discussions and articles, but eventually all the difficulties disappeared.

A curious opinion held by some engineers in the pioneer days was that small generating units were desirable. In 1891 Professor A. B. W. Kennedy is reported to have said that the best unit for a central station should not exceed 200 H.P. for the reason that with engines of larger power it was extremely difficult to keep them fully loaded, while the efficiency of a steam engine of 2000 H.P. was but little better than that of one of 200 H.P. Strange as such an opinion seems nowadays, Professor Kennedy was by no means alone in this view, for in 1904 the supply of Liverpool was provided by no fewer than seventy-eight Willans and Browett engines with a total capacity of 24,825 kW, the average size therefore being less than 320 kW apiece.

As every electrical engineer knows and as Mr. Parsons spares no pains to emphasise, the steam turbine revolutionised the generation of electricity and made the grid system possible. But as a record of the steps that led up to the present state of affairs this book is invaluable to all seeking historical information on early power station design and operation. We need scarcely add that it is written with that lucidity of style of which Mr. Parsons is a master. Apart from this characteristic a literary effect is secured by the inclusion of mottoes—as Scott called them—at the head of the chapters. These mottoes are very happily and wittily chosen, as, for example, under the heading Gas Engines as Prime Movers in Power Stations "This Power hath worked no good to aught that lives" (Tennyson) or under The Introduction of the Steam Turbine:

> "And all that moves between the quiet poles
> Shall be at my command" (Marlowe).

By the layman engineering literature is always expected to be dry and dull. This volume shows that in competent hands it need be neither, but in the word of Tweedledee "Contrariwise."

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

THE PRODUCTIVE CAPACITY OF WELDING MACHINES

SIR,—At the present time there are between 30,000 and 40,000 arc welding machines in use in Great Britain, almost all of them being used exclusively on Government and armament contracts. Many letters have appeared in the technical Press from prominent industrialists bemoaning the fact that machine tools are not working twenty-four hours a day. This contention undoubtedly applies to welding machines also, which are, of course, a form of machine tool.

However, a case for much more serious concern at the present time is the fact that during the hours that arc welding machines are used they are almost invariably not being used to their full productive capacity. This Foundation has been endowed to promote knowledge of welding, and we would recommend every engineer who uses arc welding to give serious consideration to the following points:—

(1) A welding operator seldom has his arc burning for more than four hours out of every eight. The operator spends the remaining four hours cleaning his welds, assembling the job to be welded, tacking, and doing other work which could be done by unskilled labour.

(2) Welding electrodes are seldom run at maximum currents. The rate of melting of the electrode increases as the welding current increases and welding currents can frequently be increased 10 or 20 per

cent., and can often be increased 30 or 40 per cent., thereby giving a faster rate of welding.

(3) Work is all too frequently welded with $\frac{1}{4}$in. electrodes where a $\frac{1}{16}$in. electrode can be used; a $\frac{1}{16}$in. electrode is often used where a $\frac{1}{8}$in. electrode can do the job. By using a larger electrode a weld joint can be made very much more quickly because welding is a matter of depositing metal, and it is sound economics and good engineering to use the largest electrode and the highest current possible on every job.

(4) By the use of jigs, fixtures, and manipulating devices for turning jobs being welded, the time the arc is in operation can be increased still further by turning work so that the operator is welding in the flat position, rather than in the vertical or overhead position.

We have no hesitation in stating that if engineers who control welding operations were to give some consideration to the points mentioned above the production of welded work could be increased by at least 10 per cent., and in many cases increased by 30 or 40 per cent. If only 10 per cent. increase in production were secured, this would mean 3000 or 4000 welding machines released for productive work, instead of running idle, and a like number of skilled welding operators released.

Quite apart from the above question of increasing welded production, considerable quantities of steel can be saved by redesigning existing machinery and armaments, so that such machinery, &c., can be fabricated by welding. The use of welded fabrication inherently entails considerable saving in steel as compared with other methods of manufacture. It is quite common for machinery redesigned for fabrication from welded steel to show a saving of between 10 and 20 per cent. of the weight of steel required as compared with other methods of construction.

This Foundation is again offering £40,000 as prize money for engineers who devote time and study to this question of the correct use of welding and obtaining the full benefits from welded fabrication. This prize money was endowed before the war started, but to-day it is doubly important that engineers give attention to these matters as part of the national effort.

THE JAMES F. LINCOLN WELDING FOUNDATION,
R. BUTLER,
British Representative.

Welwyn Garden City, Herts,
July 11th.

THE MATHEMATICS OF THE BALLOON BARRAGE

SIR,—In the article "The Mathematics of the Balloon Barrage" in your issue of June 21st, there appears to be a serious error.

Assuming a single circular ring of radius r feet and n balloons, and considering the centre point of the plane of span S feet, this centre point may pass through at any point in the ring of $2\pi r$ feet. If it passes within $\frac{1}{2}$ S feet of a wire, the latter will be touched; the "obstructed path" is therefore S n feet—not 2 S n—and the unobstructed path $(2\pi r - S n)$ feet.

If D is the distance between wires, then $D = 2\pi r/n$, and the probability of getting in safely is $\left(1-\frac{S}{D}\right)$, and the probability of getting in and out again safely is $\left(1-\frac{S}{D}\right)^2$.

If S = 50ft., and if the odds on getting in safely are to be 2 to 1, then

$$2=\left(\frac{1-\frac{S}{D}}{\frac{S}{D}}\right) \quad \therefore D = 150\text{ft.}$$

If the odds on getting in and out again safely are to be 2 to 1, then

$$2=\frac{\left(1-\frac{S}{D}\right)^2}{1-\left(1-\frac{S}{D}\right)^2} \quad \therefore D = 272{\cdot}5\text{ft.}$$

PHILIP LYLE.

London, E.C.3, July 12th.

GLASS FIBRE ELECTRICAL INSULATION

SIR,—With reference to the article by Dr. Quarendon which appeared in the June 14th issue of your journal, I should be glad if you would draw the author's attention to the following comments:—

(1) *Page* 538, *Column* 2.—The author refers to the ability of fibre glass to withstand severe vibration as one of the properties which has brought fibre glass to the fore as a thermal insulant. Fibre glass has been employed for thermal insulation for some years, but its use as an electrical insulant is comparatively recent—at any rate, in this country. This latter use resulted, as far as I am aware, from the introduction of the very small fibres now obtainable. Previous to this, the available glass fibres were of the order of 0·001in. diameter and decidedly brittle. These fibres were not resistant to severe vibration and it was the knowledge of this which led (contrary to your contributor's statement) to the present widely accepted view that glass fibres *per se* do not resist vibration. However, the author has no doubt based his categorical statement on experimental data, in which case I should very much like to have details.

(2) *Page* 538, *Column* 3.—Dr. Quarendon makes two statements in the second paragraph which appear to me to contradict each other. In the first sentence it is stated that "... an important advantage of glass insulation is that ... its insulating power ... is not seriously reduced ... by high humidity." In the last sentence it is stated that "... dampness arising from high humidity of the air reduces the insulation resistance of glass considerably...." My own experience leads me to agree with the latter statement. Moreover, the considerable reduction which does take place is, in my view, also serious. Perhaps the author would be good enough to explain what is meant by these two statements.

(3) *Page* 538, *Column* 3.—The author states in the penultimate paragraph that "... impregnating materials at present available limit the temperature at which glass electrical insulation can be used satisfactorily to about 100 deg. Cent...." I regard this as a very conservative estimate of the upper temperature limit. It was probably true about a year or eighteen months ago, but to-day the figure is more like 150 deg. Cent. In fact, I have information that a well-known manufacturer of electrical insulation is producing a varnished fibre glass product capable of withstanding even higher temperatures—probably over 200 deg. Cent.

In any case, on page 539, Dr. Quarendon refers to claims made in respect of a particular motor which state that "... no amount of overloading will affect the motor as long as the motor continues to turn." Also, "under test it carried 100 per cent. overload for six hours without damage." In a later sentence it is claimed of the motor that it withstood a 200 deg. Cent. temperature rise without harm. Unless I am much mistaken, these claims refer to the Brook "Indestructible" motor (in which case this latter temperature rise should be 277 deg. Cent.). This motor is claimed by the makers to have withstood 100 per cent. overload for six hours without damage despite a 389 deg. Cent. temperature rise. These figures relate to a motor which is now in production. They may therefore be said to relate to present-day practice. In view of this, I should be very interested to learn on what grounds the author states that the satisfactory use of impregnating materials is at present limited to about 100 deg. Cent.

In conclusion, I would remark that many of the statements made by Dr. Quarendon have already appeared in the American technical press—often without a shred of evidence to support them. From the same source have come various claims for impregnated fibre glass, which claims have often been based on test results obtained with the unimpregnated product. In this country, however, no authoritative test data on glass fibre have hitherto been published. Knowing this, I am reluctantly forced to the view that the present article is, for the most part, a *résumé* of American articles on the subject. I should, however, be very pleased to hear from the author that he writes from first-hand knowledge of the subject. In fact, it is my chief object in writing this letter to ascertain whether or not the author's remarks are founded on personally verified experimental evidence.

Ewell, Surrey, H. L. D. WYMAN, A.M.I.E.E.
June 28th.

SIR,—Mr. Wyman is right in supposing that my article was a review and not a record of personal experience. However, I hope that it was not on that account any the less interesting to those of your readers not perhaps quite as well informed on this subject as Mr. Wyman.

With regard to the question of vibration, although the coarser fibres of the earlier days were undoubtedly brittle, the later continuous filaments employed for glass silk insulation were much better. I think I am right in saying that these are appreciably finer than 0·001in. diameter.

Perhaps I did not express myself as clearly as I might have done when writing of the effect of humidity. What I meant to convey was that, although high humidity reduces the insulation resistance of glass, this is in practice not such a disability as might be thought, because the apparatus suffers no permanent harm.

I agree that the figure of 100 deg. Cent. quoted for the maximum temperature at which glass electrical insulation can be used satisfactorily is now too low. In fact, the makers of the motor referred to state that impregnating varnishes now available permit working temperatures of about 150 deg. Cent. The higher temperatures claimed may be for overload conditions for a short while, as opposed to continuous operation.

Redcar, Yorks, R. QUARENDON.
July 11th.

Sixty Years Ago

THE "LIVADIA"

THE evolution of the shape of ships from the coracle to the modern liner presents a highly instructive field of study. It is marked by many curiosities and not least so in that portion of it covering the nineteenth century. Our fathers and grandfathers were less certain than we are to-day that the evolution of ship form was approaching finality in all but detail and received with tolerant credulity the claims made for many strange shapes which to-day we would reject as grotesque. They hailed with interest the "cigar ship" with the propeller midway down the length of its hull, the twin hull ship with the paddle wheels between the hull, the circular ironclads or "cyclads" built for the Russian Navy to the designs of Admiral Popoff, and many another major or minor freak. Sixty years ago in our issues of July 9th and 16th, 1880, our pages contained pictures and particulars of the latest marine wonder, the steam yacht "Livadia," built for the Tsar of Russia by John Elder and Co., of Govan. This strange vessel, held by enthusiasts "to inaugurate a new era in naval architecture," had a length of 235ft., a beam of 153ft., and a draught of 6ft. 6in. She was not altogether a reproduction of the Popoff circular warships, but possessed a definite bow and stern. In profile she looked like an ordinary ship, but in plan she had the appearance of a turbot or other flat fish. She may perhaps be best described as an ordinary ship constructed to plans the athwartship dimensions of which had been drawn to a greatly enlarged scale relatively to the scale of the longitudinal dimensions. The actual hull was flat-bottomed and turtle-backed, and on top of it was reared a high superstructure devoted to state saloons, imperial boudoirs, accommodation for grand dukes, attendant suites, officers, and crew. Within the turtle back hull proper eight main boilers were arranged in an athwartship row. They supplied steam to three compound engines driving triple screws. The three funnels were arranged in line across the width of the deck. The actual width of the deck was less than the 153ft. beam, as measured over the hull proper. As a consequence, beyond the sides of the superstructure there appeared above the water line a portion of the turtle back top of the hull. Flying bridges gave access from the deck to flights of steps leading across the turtle back to the water line. Although the ship's internal appointments were of a luxurious nature, we detected in the manner in which she was subdivided and in other features of her design a possibility that she might readily be converted to purposes other than peaceful. The ship was up to date in two respects; she was lit by electricity and her hull and boilers were made of steel. Trouble arose with her boilers even before she went to sea. Under hydraulic test the plates cracked before the full pressure was applied. The boilers were reconstructed in iron. On the voyage out to the Black Sea she was reported to have struck some floating wreckage, and had to put into Ferrol in a leaking condition. A number of people suspected, however, that the impact of the flat bottom on the water when the ship pitched had cracked the steel plates of her hull, and contended that this incident and the failure of her boilers demonstrated the unsuitability of steel as a shipbuilding material.

CIVIL LIAISON.—Many professional people for whom the Government has not yet found suitable work are desirous of helping with the war. Mr. A. B. Cox ("Francis Iles") has formed an organisation under the name of "Civil Liaison" for such would-be workers. The Technical Section of Civil Liaison is now linked with the Research Co-ordination Committee (formed several years ago), and it is considered by these bodies that one of the first things with which they can help is to invite the public, especially technicians, to send, for the consideration of the expert members of these bodies, useful ideas with which Government Departments have been unable to deal. Any suggestions which the experts consider good will be developed, if necessary, and put before the appropriate Government Department with the backing of our experts. Other sections are being organised to use all the technical talent freely offered. Those interested are invited to write to the Technical Section, Civil Liaison, 86, Hamilton Terrace, London, N.W.8.

Discriminative Overcurrent and Earth Leakage Protection

THE interconnection of large power stations and their distribution systems have made possible the liberation of great amounts of electrical energy in the event of a fault. For safeguarding the electrical plant and transmission lines and for maintaining continuity of supply automatic protective systems have therefore become of considerable importance.

One of the earliest and simplest means of protecting almost all classes of electrical apparatus was the provision of overcurrent and leakage protection and, although in recent times many specialised schemes have been evolved for dealing with various types of apparatus, the overcurrent and earth leakage principle remains the most universally employed. Simplicity, reliability and economy are the main factors that have made the system popular.

The types of overcurrent and earth leakage apparatus made by the General Electric Company, Ltd., of Magnet House, Kingsway, W.C.2, range from the direct-acting coils used in small switchgear to the

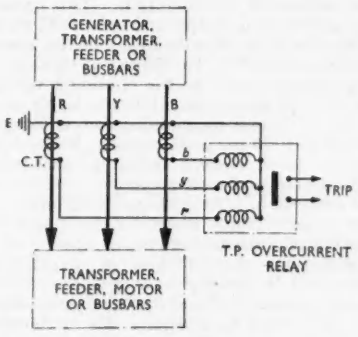

FIG. 1—OVERCURRENT PROTECTION FOR THREE-PHASE THREE-WIRE OR THREE-PHASE FOUR-WIRE

modern current transformer relays operating in conjunction with the largest circuit breakers. The diagram Fig. 1 shows a simple overcurrent group consisting of three current transformers and a three-element relay. Excess current in any phase is reproduced in the secondary of the current transformer and hence in the relay. At a predetermined current value the relay operates so as to close its contacts, thereby tripping the associated circuit breaker. A simple earth leakage scheme is illustrated in Fig. 2. Under all conditions, normal and abnormal, no current will flow in the relay so long as the sum of the phase currents is zero. But if an earth leakage develops the sum will no longer be zero and an out-of-balance current will flow in the relay coil, causing it to operate.

The induction type relay with inverse and definite minimum time characteristic (Fig. 3) is now the most common relay in use. With an operating element in the form of an eddy current induction disc motor it

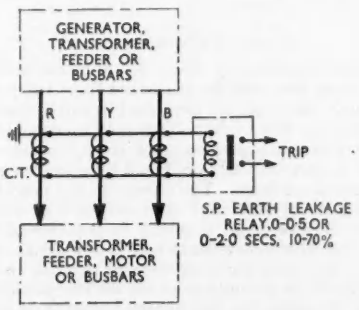

FIG. 2—EARTH LEAKAGE PROTECTION FOR THREE-PHASE THREE-WIRE OR TWO-PHASE THREE-WIRE

operates in a time that varies inversely as the operating current, down to a limiting value, when the delay becomes sensibly constant regardless of further increase of current. The discriminating feature of the relay is embodied in the motor disc, the timing of which can be varied by altering the distance through which the disc rotates. The current setting is made in connection with the operating coil, which is tapped and connected to a plug setting board giving a 4 : 1 current range in seven tappings. Hence with this system of protection the breakers controlling various sub-circuits can be timed so as to open in predetermined sequence in the event of a fault. In this way general interruption of supply on account of minor faults or local overloads is avoided.

In the diagram Fig. 4 the timing characteristics of the relay are shown. Curve A indicates the characteristics for a 2 sec. d.m.t. (definite minimum time) setting, while curves B, C and D represent settings of 1·5, 1·0 and 0·5 sec. d.m.t. respectively. Comparing, for example, curves A and C, it will be seen that, for any value of current, the time ordinate of C is always half that of A. Any other time setting gives an operating time in proportion. The current scale is graduated in percentage of plug setting, so that, for a 200/5-ampere current transformer operating with a relay on the 125 per cent. plug setting, the primary current corresponding to the 400 per cent. ordinate is $\frac{400}{100} \times \frac{125}{100} \times 200$ amperes = 1000 amperes, and the corresponding time of operation is 2·5 sec. at the 2 sec. d.m.t. setting, 1·25 sec. at the 1 sec. d.m.t. setting, and so on for other settings.

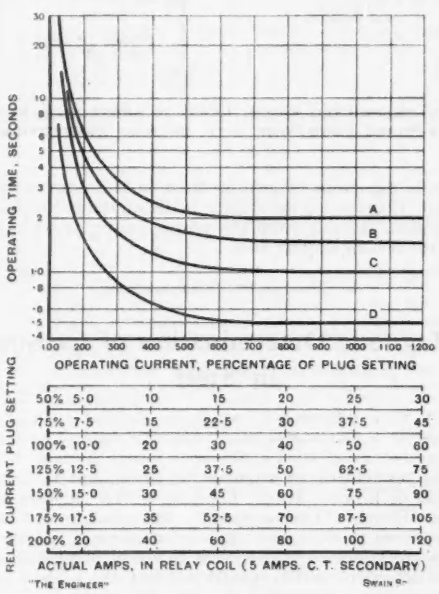

FIG. 4—TIMING CHARACTERISTICS OF A THREE-POLE OVERCURRENT RELAY

The table below Fig. 4 shows, for various settings, the actual currents in a relay coil fed from a current transformer designed to give a secondary current of 5 amperes at full load. The curves A, B, C and D may be regarded as the settings of four different relays protecting four different pieces of apparatus on the same supply system. For overloads in excess of approximately 650 per cent. of full-load current—as, for example, a short circuit—the curves all run parallel to the base, and the relays will operate in definite sequence in 0·5, 1·0, 1·6 and 2 sec. respectively. Positive time discrimination is thus secured, so that the circuit breaker nearest to the fault will open before any of the others is affected.

Considerable importance attaches to the correct design of current transformers used in connection with overcurrent and earth leakage relays, particularly with the latter. Most standard 15-VA Class C transformers are suitable, but where bushing or through type transformers having only one primary conductor are used for currents less than 1000 amperes, care must be taken to ensure sufficient secondary overload capacity to bring the overcurrent relay to its definite minimum time. When such current transformers have to operate in conjunction with an earth leakage relay it is desirable that they should be accurately balanced and have no other secondary burden to upset this balance. The earth leakage arrangement shown in Fig. 2 ensures maximum sensitivity and stability.

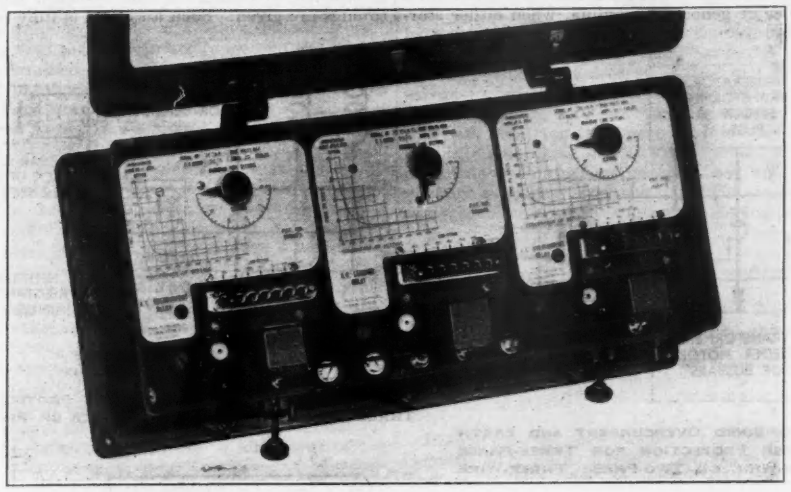

FIG. 3—THREE-POLE OVERCURRENT RELAY

Similar precautions are necessary when low ratio wound type current transformers, designed for maximum fault currents exceeding approximately fifteen times their normal rating, are used.

The main applications of the relays described are the protection of (*a*) generators, (*b*) bus-bars, (*c*) transformers, (*d*) feeders, both overhead and underground, and (*e*) motors. The arrangement in Fig. 1 is applicable to all the five types of apparatus listed. The relay must be set to operate at a current in excess of the normal full load of the apparatus protected, and the timing adjusted with relation to that of associated gear. Instruments can be connected in series with the

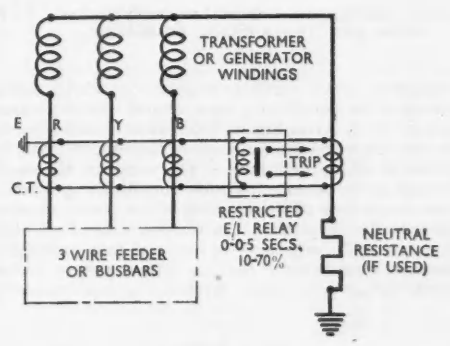

FIG. 5—RESTRICTED EARTH LEAKAGE PROTECTION FOR THREE-PHASE THREE-WIRE

relay, when average current transformers are used, without detriment to the protection.

The three-wire earth leakage arrangement shown in Fig. 2 affords an effective means of rapidly isolating an internal earth fault within a power transformer. A d.m.t. setting of about 0·2 to 0·5 sec. ensures stability against current transformer errors caused by switching surges and heavy through fault currents. A relay current of 10 per cent. can generally be used with complete stability. This class of protection can also be employed for earth fault protection on feeders, and is generally adopted on industrial gear, such as the sensitive earth leakage protection of cables in mines, where settings as low as 5 per cent. of normal full load can be obtained. This arrangement can also be applied to the protection of motors, but the method shown in Fig. 5 is usually employed. As an alternative to the three-line current transformers a single-core balance current transformer embracing all three phases can be used. With either arrangement the results obtained are identical.

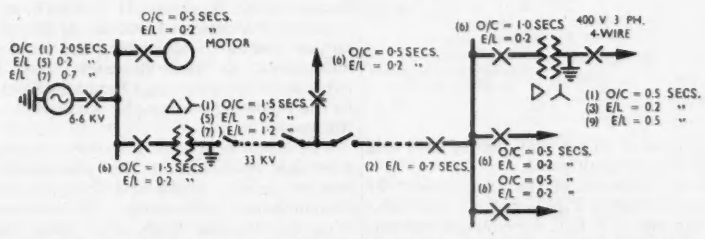
O/C = 0·5 SECS.
E/L = 0·2 "
O/C (1) 2·0 SECS.
E/L (5) 0·2 "
E/L (7) 0·7 "
MOTOR
6·6 KV
(1) O/C = 1·5 SECS.
(5) E/L = 0·2 "
(7) E/L = 1·2 "
(6) O/C = 1·5 SECS.
E/L = 0·2 "
33 KV
(6) O/C = 0·5 SECS.
E/L = 0·2 "
(2) E/L = 0·7 SECS.
(6) O/C = 1·0 SECS.
E/L = 0·2
400 V 3 PH. 4-WIRE
(1) O/C = 0·5 SECS.
(3) E/L = 0·2 "
(9) E/L = 0·5 "
O/C = 0·5 SECS.
(6) E/L = 0·2 "
(6) O/C = 0·5 "
E/L = 0·2 "

FIG. 6—SCHEME OF DISCRIMINATIVE OVERCURRENT AND EARTH LEAKAGE PROTECTION

The arrangement given in Fig. 7 is probably the most popular form of overcurrent and earth leakage protection. It affords full protection with only three current transformers and a minimum of three relay elements, which can be housed in one triple-pole case, and is used successfully for the protection of transformers, feeders and motors. Given average current transformers, protection equivalent to that provided by the arrangements shown in Figs. 1 and 2 combined can in many cases be obtained.

One of the best forms of earth fault protection for a transformer or generator winding, when either star-connected with earthed neutral or when delta-connected and employing an inter-star earthing transformer, is shown in Fig. 5. Protection is restricted to the windings and the connections thereto, and only in the event of an earth fault in this zone will the earth leakage relay operate. Faults outside the protected zone, regardless of the location of the power sources, do not affect the relay. In the interests of stability it is generally advisable to use the four associated current transformers for no other purpose than earth leakage protection. With average current transformers a relay setting of 10 per cent. can be used and a d.m.t. of 0·2 sec. is recommended.

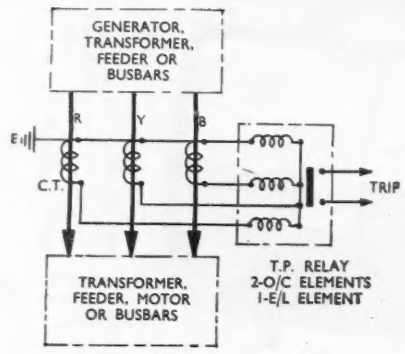

FIG. 7—COMBINED OVERCURRENT AND EARTH LEAKAGE PROTECTION FOR THREE-PHASE THREE-WIRE OR TWO-PHASE THREE-WIRE

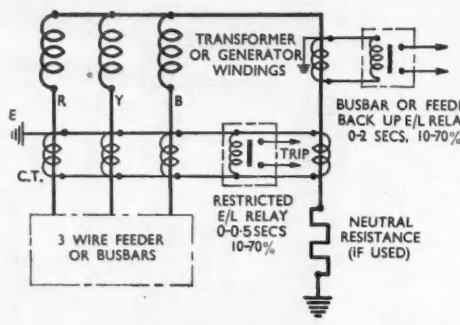

FIG. 8—RESTRICTED EARTH LEAKAGE PROTECTION FOR THREE-PHASE THREE-WIRE WITH BACK-UP PROTECTION

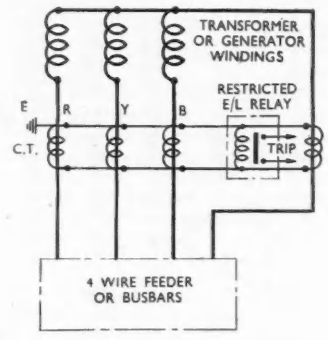

FIG. 9—RESTRICTED EARTH LEAKAGE PROTECTION FOR THREE-PHASE FOUR-WIRE

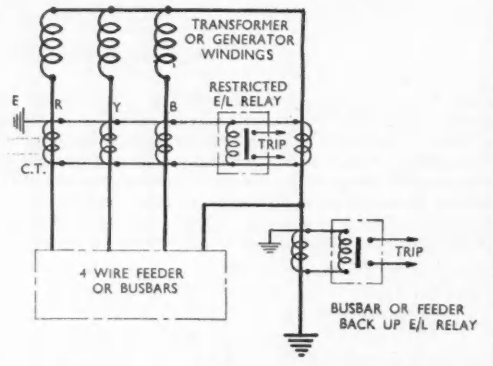

FIG. 10—RESTRICTED EARTH LEAKAGE PROTECTION FOR THREE-PHASE FOUR-WIRE WITH BACK-UP PROTECTION

The principle of operation of the arrangement in Fig. 9 is the same as that in Fig. 5, but a fourth wire is shown, as in the case of a L.T. distribution system. Here also the earth leakage relays operate only in the event of an internal fault and are immune from all other conditions of unbalance. Settings similar to those shown in Fig. 5 are recommended. Back-up earth leakage protection can be applied to perform one or several of a variety of operations. As applied in both Figs. 8 and 10, it provides a back-up to the restricted earth leakage group. The setting must not be below that of the connected apparatus. A setting from 1 to 2 sec. is usual. As applied to Fig. 5 when a neutral earthing resistance is used, the relay can be set with relation to the thermal rating of the resistance.

Discriminative overcurrent and earth leakage protection of a complete system, including generator, bus-bars, transformers, feeders and motors, is shown in the diagram in Fig. 6. All five types of equipment are interconnected in a manner typical of modern practice. The various forms of protection shown in Figs. 1, 2, 5, 7, 8, &e., are indicated by the numbers in brackets preceding the time settings, and suitable timings are given. Such a system is fully protected, and a minimum of gear isolated in the event of a fault. Considering the scheme in detail, the protection afforded, starting from the power source, is set out in the accompanying table.

Apparatus.	Protective group.	Extent of protection.
	Fig.	
Generator	1	Excess of current.
	5	Internal earth faults.
6·6-kV bus-bars (current transformer in generator neutral)	7	Earth faults.
6·6-kV motor	6	Excess current.
		Internal earth faults.
6·6/33-kV transformers	6	L.V. phase faults.
		L.V. earth faults.
	5	H.V. earth faults.
	1	L.V. and H.V. excess currents.
33-kV transmission line	1	Excess currents.
	7	Earth faults.
Tee off	6	Excess current.
		Earth fault.
33-kV bus-bars	2	Earth faults.
33-kV/400-V transformers ...	6	H.V. and L.V. phase faults.
		H.V. earth faults.
	8	L.V. earth faults.
	1	H.V. or L.V. excess currents.
400-V distribution	1	Excess current.
	9	Earth fault.
33-kV feeders	6	Excess current, phase or earth faults.

Magnetic Determination of Carbon in Steel

A NEW instrument, which is claimed to make possible a closer and more scientific control of the manufacture of steel in the open-hearth furnace, has been brought to our attention by Griffin and Tatlock, Ltd., of Kemble Street, London, W.C.2. Known as the Fisher "Carbanalyzer," the instrument is employed to determine the carbon content quickly. We are informed that with it the steel plant melter can determine within $\pm 0{\cdot}02$ per cent. the amount of carbon in a steel bath in three to five minutes. It is pointed out that a chemical determination of carbon in steel requires a longer time, about fifteen or more minutes, and that time is of the utmost importance, because the carbon content of a steel bath changes rapidly and must be carefully controlled. Messrs. Griffin and Tatlock are agents in this country for the instrument, which was developed by the Jones and Laughlin Steel Corporation and is manufactured by the Fisher Scientific Company, of Pittsburg, Pa., U.S.A.

Technical details of the instrument are given by Messrs. H. K. Work and H. T. Clark, in a paper read before the American Institute of Mining and Metallurgical Engineers, describing the development of the instrument at the Research and Development Division of the Jones and Laughlin Steel Corporation. In the following paragraphs we reprint excerpts from this paper.

The instrument was developed originally to facilitate the operation of the pilot-sized open-hearth furnace in the Jones and Laughlin Research and Development Laboratory. In this small furnace, with its shallow bath, the drop in carbon is accelerated, and a rapid, reliable test for carbon content is indispensable. This problem becomes rather acute when it is desired to finish heats at a carbon content higher than can be estimated with any degree of accuracy by the fracture test. Several independent methods for determining carbon were investigated, therefore, and it was found that a relatively simple magnetic device could be made to give reproducible results. A laboratory instrument was designed and set up for the use of the furnace operators. It was tested exhaustively in the laboratory and was used with considerable success for following the carbon content in the furnace bath. As soon as sufficient data had been compiled to indicate that the instrument might have a wider application, a more rugged model was constructed and placed in the mill to be tested on commercial heats. Finally, about a year ago, instruments were furnished to the plant open-hearth shops and these have been in use since that time.

Several investigators have considered the problem of evaluating carbon content by one or another of the magnetic properties. Of considerable historical interest is the work of the Reverend William Scoresby[1], who, in 1839, recorded some attempts to determine the carbon content of steel by measuring the retentivity of a magnetised specimen, and that of C. M. Ryder,[2] who described an instrument for the same purpose in the "Transactions" of the A.I.M.E. for 1876.

During the last twenty years of the last century, various instruments were developed for measuring accurately the magnetic properties of transformer steel and similar materials, and thought was given to the relationship between these properties and carbon content of the materials. Two consecutive articles on the subject appear in the 1896 volume of the "Minutes of the Proceedings" of the Institution of Civil Engineers.[3,4] The former of these described the equipment necessary for obtaining the permeability of steel specimens, while the latter gave flux densities, at various magnetising forces, for steels of from 0·17 to 0·70 per cent. carbon. Madame Curie,[5] two years later, showed definitely that the flux through a hardened steel specimen is related to the carbon content, at a fixed magnetising force.

More recently three magnetic methods for rapid evaluation of carbon content in steel have been developed. The first of these is embodied in the carbometer of Malmberg,[6–9] the second in the Bureau of Mines coercimeter [10] and the third is a comparison method developed by Blosjo.[11] The carbometer, in principle, resembles a permeameter, except that the change in flux in the specimen is produced by a mechanical arrangement involving the use of a permanent magnet and rotating soft steel bars. A cam mechanism within the instrument produces a set number of reversals of flux in order to put the specimen in a standard state, and completes the galvanometer circuit only for the final change in flux, which produces the reading. By this arrangement the ballistic galvanometer receives a single impulse. The coercimeter makes use of another magnetic property—the coercive force—which has been defined as "the intensity of the magnetic field that must be applied in the direction opposite to that in which the specimen was originally magnetised to reduce the magnetic flux to zero." The procedure, briefly, consists in magnetising the specimen in a powerful electromagnet, then transferring it to a calibrated solenoid coil, and measuring the current in the coil necessary to reduce the magnetic field of the specimen to zero. Blosjo's method depends on the change in permeability with change in carbon content, and compares the test specimen with a standard bar of about 0·21 per cent. carbon. It is essentially a null method, except that the small readings for unbalanced samples are used for calibration.

General Considerations

Various methods by which the fundamental magnetic quantities may be measured have been known for many years and are described in the literature on the subject. The Carbanalyzer may be considered as a special form of a permeameter, since it measures the change in flux in a bar produced by a known change in magnetising force. The change in the magnetising force (Δ H) in this case is equal to 2 H and the change in flux ($\Delta \varphi$) is equal to 2 φ, because the current in the magnetising coil is reversed. Therefore, if the cross-sectional area of the bar specimen is known, it is possible to calculate the permeability of the material, for the known value of H, by the application of the ordinary magnetic equations.

The absolute value of the various quantities are of no interest in the present application; attention is paid solely to galvanometer deflections for a reversal of a given magnetising current, and these deflections are calibrated in terms of carbon content. The main objectives in this work have been:—(1) Accuracy and reproducibility of results, (2) ease and speed of operation, and (3) simplicity and ruggedness of equipment.

Construction Details

The details of the electrical circuit of the Carbanalyzer are shown in the diagram—Fig. 1. Coils A and B are the primary and secondary of a special induction coil. The current in the primary coil is supplied by battery C, measured by meter D, controlled by rheostat E, and reversed by switch F. The other double-pole, double-throw switch G is inserted in order that the same meter may be used in both the primary circuit (in parallel with the resistance H) to measure the steady current, and in the secondary circuit as a ballistic instrument. The meter is a millivoltmeter and is designed to be short-circuited when not in use to prevent damage to the moving parts. This feature is used to advantage; the meter is short-

circuited to protect it during the several reversals of current necessary to put the specimen in a standard state. The push-button switch J in its normal position short-circuits the meter through the shorting terminal K. When pushed down for a reading it releases the meter and lights, by means of battery L, a group of flashlight bulbs M above the meter scale.

The millivoltmeter has a fairly rapid motion when used as a ballistic instrument, but has been used advisedly since it is satisfactory in a portable machine and may be read accurately by the aid of a small two-power reading glass mounted above the meter face.

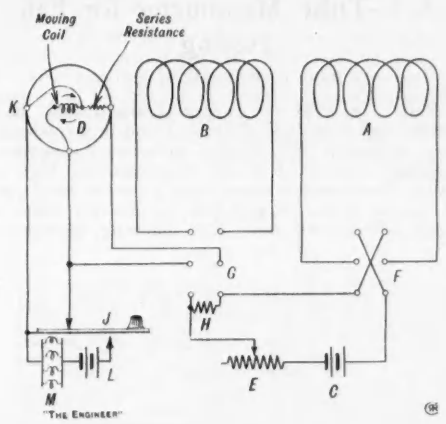

FIG. 1—ELECTRICAL CIRCUIT OF CARBANALYZER

Likewise, it does not require levelling, holds its zero setting well, and is not affected by any normal mill vibration. Other electrical parts, with the exception of the magnetic unit, are standard equipment.

The magnetic unit is shown in Fig. 2. The primary and secondary coils are wound on a hollow bakelite form and held in position between the two heavy steel plates forming the sides of the yoke. The cylindrical specimen is thrust through the holes in the yoke and the coils, and is held in good magnetic contact with the yoke. This is a closed magnetic circuit and stray magnetic fields in the vicinity cause

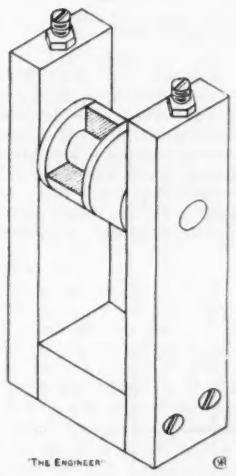

FIG. 2—MAGNETIC UNIT

no difficulty. The specimen may be inserted and withdrawn readily and will always be held in the same position with the same sidewise thrust against the soft steel yoke. It has been amply demonstrated in repeated tests on the same specimen that the readings are reproducible, showing that the same magnetic coupling is attained each time the specimen is inserted. The size and shape of the specimen may be varied through relatively wide limits, although care must be taken that only specimens of the type for which the machine was calibrated are used.

One machine may be required to follow at the same time two or more heats with very different carbon contents, and it was considered desirable to use a single setting for both the high range and low range of carbon content. The Carbanalyzer has been so designed that it is possible for readings to be taken on high-carbon and low-carbon samples alternately with no change in the instrument. The deflections do not overlap and there is no possibility of confusion. At the same time, the accuracy, in terms of carbon content, has been found to be quite satisfactory.

PREPARATION OF SPECIMEN

The original experimental work included a study of the magnetic characteristics of specimens quenched under various conditions. It was found that a delayed quench was satisfactory for steels with carbon content below about 0·40 per cent., but that for carbons higher than that the readings were not selective. A rapid quench was then tested for the range from 0·20 up to 1·50 per cent. carbon, and the results indicated that this method gave selective values from 0·35 per cent. carbon up to 1·50 per cent. or higher. The following procedure was adopted :—A sample of metal was taken from the bath, killed with a measured quantity of aluminium, and cast in a split mould. The specimen was removed from the mould and quenched immediately for higher carbon contents, or left in the mould for a predetermined time—one minute—and then cooled in cold water, for the low-carbon steels. For steels that were known to contain from 0·30 to 0·50 per cent. carbon, but where the amount was known only approximately, a sample was taken following each procedure, and the appropriate range and the carbon value determined from the two readings. It was standard practice to break each sample after the reading had been taken in order to be certain that the internal structure was sound.

During and at the end of a mill trial a careful search was made for possible improvements. This study resulted in the Carbanalyzer in its present form. The magnetic unit shown was designed to provide uniform magnetic coupling between the specimen and the yoke, and to require a very small current from the dry cells for its operation. Certain other minor changes were made at the same time. The procedure described above, however, was used for preparation of the specimens. One of these new instruments was then placed in each of the company's mills and was calibrated there. Reports have been favourable and the Carbanalyzers have met the requirements of the operators.

The instrument has been shown in exhaustive tests to be sufficiently accurate to fill a need of the industry. It is relatively inexpensive, requires little upkeep, and can be used by the furnace melter. It may be set up in the open-hearth shop in any reasonably clean situation. Temperature changes cause the current to change slightly, but the instrument is in correct calibration as soon as the current has been set at the correct value. The accuracy of the determination on a single sample has been shown to be good, while the average of three or more samples taken in rapid succession is highly accurate.

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Glass Reinforcement for Concrete

GLASS has a large variety of uses. But it remains surprising to find it being considered as a substitute for steel. Yet two architects, Mr. A. W. Soden, A.R.I.B.A., and Mr. John A. Lincoln, have developed a system by which glass strips are used in place of steel rods for the reinforcement of concrete. At the end of last week we attended a demonstration at the showrooms of Pilkington Brothers Ltd., 63, Piccadilly, London, W.1, of glass for just that purpose. The architects state that glass actually has certain advantages as compared with steel. They claim that in reinforced concrete beams the tension taken by the steel rods is equal to the compression taken by approximately only the top third of the concrete, and that therefore the remaining two-thirds of the concrete is mechanically wasted as regards load bearing and merely acts as a binding agent and in shear ; that it has been found that by substituting glass reinforcement for the steel the neutral axis is lowered and more concrete is brought into play for compression ; and that as the glass cross-sectional area is three times that of steel hardly any concrete is wasted.

We were able to see a number of typical beams reinforced with glass. The reinforcement takes the form of strips $\frac{5}{16}$in. thick with a depth equal to one half that of the beam to be reinforced. One edge of the glass is not cut, but is left in the fire-finished form, known as the selvedge, in which it comes from the process. That fact is important, as it has been found that polishing and refining weakens the glass and that the cut edge is not capable of taking strain. The strips of glass, which have rough surfaces, just as they came from the process, are placed in the beam with the selvedge lowermost and the cut edge on the neutral axis where it will not be subjected to strain. It is claimed that when this kind of glass is used in this manner the cost is less than that of steel. The bond between the glass and the concrete is good. It is, in fact, suggested that the alkali in the concrete slightly affects the glass surface with the result that in a period of a month or so the two materials in effect become welded together.

In the following report by Mr. J. W. Marshall some details are given of tests carried out at the City and Guilds Structural Laboratory, South Kensington.

TESTS ON GLASS REINFORCED CONCRETE

Materials.—The concrete used throughout the tests was a 1 : 2 : 3 mix of rapid-hardening Portland cement, well graded clean river sand and $\frac{3}{4}$in. ballast, except for specimen 5, where a $\frac{1}{4}$in. ballast was used for the concrete between the glass strips. A wetter mix was used for the lower part of the beams to facilitate consolidation. The glass reinforcement was supplied by Pilkington Brothers Ltd., and consisted of strips averaging $\frac{5}{16}$in. thick by $2\frac{1}{2}$in. deep. Details of the specimens are given in the following table :—

Specimen No.	Cross section.	Length.	Reinforcement.
1	12in. × 4½in.	4ft. 6in.	Ten strips at 1¼in. centres
2	,,	,,	,,
3	,,	,,	Six strips at 2in. centres
4	,,	,,	,,
5	,,	,,	Ten strips at 1¼in. centres
6	,,	2ft. 3in.	,,
7	,,	,,	Six strips at 2in. centres

In each case the glass was placed vertically with the bevelled edge flush with the underside of the slab. Test cubes were also made to give the crushing strength of the concrete used. The specimens were in all cases tested after seven days.

Bending Tests.—The tests carried out were of two types, bending and impact. The bending test was carried out on specimens 1–5 in a Riehlé test machine. The beams were supported at 4ft. centres, plywood strips being placed over the knife edges to eliminate local crushing on the glass. Point loads were applied at a distance of 15in. from each support.

The results of the tests are summarised as follows :—

Specimen No.	Bending moment.		Design moment (Soden).	Factor of safety.
	First crack.	Failure.		
	lb.-in.	lb.-in.	lb.-in.	
1	56,300	64,800	26,700	2·43
2	60,500	61,800	,,	2·31
3	34,500	45,300	16,000	2·83
4	43,800	45,100	,,	2·82
5	57,000	63,600	26,700	2·38

Deflection readings taken during the test showed no appreciable deflection at one-third of the failing load and at about 60 per cent. of the failing load the deflection was 0·02in. Failure came suddenly and was of the type usually obtained with brittle materials. On reaching the maximum load complete collapse occurred as distinct from ordinary reinforced concrete, where complete collapse does not occur until some time after the maximum load has been reached.

Impact Tests.—The impact tests were carried out by dropping a 16-lb. weight from various heights on to the specimen which was supported at 1ft. 9in. centres on a plaster of paris bed 1in. wide. The results of the tests were as follows :—

Specimen No. 6.—Ball dropped from 6ft. height caused slight cracking on some of the glass strips ; on again dropping the ball from this height very appreciable cracking of the glass occurred ; the upper surface of the concrete was not damaged. Probable ultimate momentum absorbed, 112 ft.-lb.

Specimen No. 7.—Ball dropped from 4ft. height had no effect ; ball dropped from 6ft. height caused complete failure. Probable ultimate momentum absorbed, 88 ft.-lb.

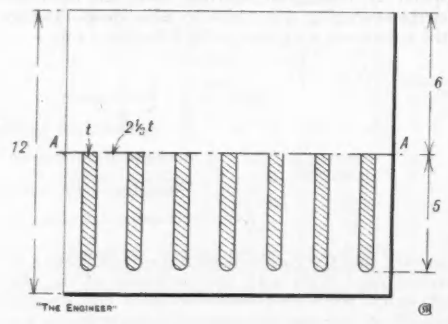
It is realised that these tests as they stand have little value due to lack of figures for an ordinary reinforced concrete slab under similar conditions, but a summary of certain impact tests on reinforced concrete may provide useful comparison. A concrete slab, 2½in. thick, reinforced with 0·094 square inch of steel and supported at 2ft. 6in. centres, absorbed 144 ft.-lb. of momentum and showed failure by crushing of the concrete at the point of impact and spalling-off on the underside. The crushing tests on the concrete cubes gave an ultimate strength in direct compression of 3920 lb. per square inch.

Conclusions.—The factor of safety for specimens 3 and 4 is comparable with ordinary reinforced concrete under similar tests, that for specimens 1, 2 and 5 is somewhat lower. The safe moment was based on the values given by Mr. Soden. The impact tests compare unfavourably with ordinary reinforced concrete. My recommendations are that for static loading of such an intensity that the reinforcement need not be placed closer than 2in. centres, glass provides a good substitute for steel ; in cases, however, where there is any likelihood of impact loading it should not be used.

It will be seen that though in straightforward bending glass reinforcement compares satisfactorily with steel it will not stand up to as high an impact load. Its inventors, however, had in mind the saving of steel in the construction of air raid shelters, and it

is claimed that the difficulty can be overcome for that purpose by a number of methods. For more general engineering purposes the material has two further disadvantages, in that a beam does not, by yielding before failure, give warning of its condition and because the maximum span length is at present limited by the length of glass strip available to 20ft. Further research is, however, being conducted with the object of ridding the material of these disadvantages.

It is an interesting fact that "Armourplate" glass is not suitable for reinforcement, quite apart from the additional cost that would be involved. In that glass there is an inner core which is in a state of tension relative to the outer crust which is in compression. If used as a reinforcing bar and subjected only to tension, the tension in the beam is added to that in the glass with unsatisfactory results. Research



ARRANGEMENT OF REINFORCEMENT IN BEAM

is, however, being carried out with toughened glass and with glass fibres. The latter have a comparative strength many times greater than that of steel.

As will be observed from the foregoing, the new material has been developed by its inventors with a relatively minor structural object. But when research has indicated in what manner reinforced concrete design can best be modified to suit the particular qualities of glass reinforcement; and when, perhaps, a form of glass particularly suited to the purpose has been developed, it is by no means impossible that the new material will find uses in a larger field. For those who may be interested, therefore, we reprint below some extracts from calculations made by Messrs. Soden and Lincoln.

Position of Neutral Line.—The data assumed for concrete and glass are as follows:—

Young's Modulus.

Concrete	2,000,000 lb. per square inch
Glass	10,000,000 lb. " "

Limiting Safe Stresses.

Concrete	600 lb. per square inch (in compression)
Glass	2500 lb. per square inch (in tension, fire-finished surface)

In a beam of depth d inches, the neutral line will be at a depth from the top such that when the compression in the top layer introduces a compressive stress 600 in that layer, the tensile stress in the bottom layer will be 2500. Since glass has a Young's modulus five times that of concrete, the relative compression and extension to give these stresses will be proportional to 600 and 2500/5, *i.e.*, 600 and 500. This compression and the corresponding extension are proportional to the distances of the upper and lower surfaces of the beam from the neutral line; consequently if the full depth of the beam is represented by 11, the compression zone (from the top down to the neutral line) will be represented by 6, and the tension zone (from the neutral line to the bottom of the beam) is of depth 5.

Cross-sectional Areas of Concrete and Glass.—Since glass is so much weaker than steel, a relatively large cross-sectional area will be needed, and it cannot be assumed that the glass can be introduced as a thin rod with its centre at the lower limit of the tension zone. No part of the glass must lie below this limit, otherwise it will be stressed to an amount greater than 2500 lb. per square inch, when the concrete is loaded to 600 lb. per square inch.

We must imagine the glass to be distributed throughout the full depth of the tension zone in order to find what cross-sectional area may be needed. When the beam is loaded the compressions in the concrete must just balance the tensions in the glass, *i.e.*, $\frac{1}{2}\,600\times 6\,b=\frac{1}{2}\,2500\times 5\,y$, which gives $36\,b=125\,y$ where b and y are the widths of concrete and glass respectively, or

$$y=\frac{36\,b}{125}=0\cdot 288\,b.$$

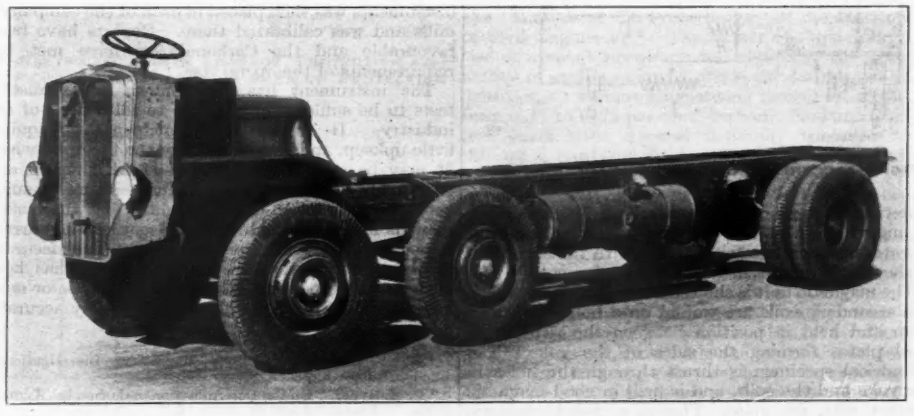
The stresses will be balanced therefore if the width of the glass section is only 0·288 times the width of the concrete. For convenience it will be taken that $y=0\cdot 3\,b$.

Suggested Construction.—The foregoing results indicate that the most economical construction would be to construct the beam of uniform cross section throughout, the upper half being solid concrete and the lower half being made with vertical strips of glass embedded in the concrete at distances such that the separation between the strips is 2½ the thickness of each strip. The vertical dimensions of the strips would be not quite equal to the half-depth of the beam; this would be made up allowing a small "cover" for the under edges of the glasses. The proportions are indicated in the sketch.

It would be of some advantage to allow the glasses to penetrate a little way above the neutral line A A so as to ensure the top (cut) edge being in compression.

Twin Front Axle Six-Wheeled Vehicles

THREE vehicles of the twin front axle six-wheel type have recently been placed in service by Northern operators. They are the first examples of a new model, illustrated herewith, which has been developed by the Associated Equipment Company, Ltd., of Southall, as an alternative to the "Mammoth Minor" chassis. Its principal use is in transporting loads where the weight is unevenly distributed and greater on the fore part of the vehicle than on the rear. In such cases the twin front axle arrangement tends to make the steering easier.



TWIN FRONT AXLE SIX-WHEELED VEHICLE

These vehicles are the only ones so far supplied by the firm, and the new model will not be put into production during the war period.

In general equipment the new chassis resembles the "Mammoth Minor." It is fitted with a six-cylinder, 7·7-litre, direct-injection oil engine, a four-speed gear-box and a double-reduction bevel rear axle. A booster gear-box can be fitted. The twin front axles embody certain changes of lay-out, but generally follow those of the "Mammoth Major 8," and the steering mechanism is of the A.E.C. worm and nut type.

Dewandre-Lockheed brakes, actuated by a foot pedal, are used for the front and rear axles and a ratchet type hand brake of the double-pull pattern operates on the intermediate rear axle.

Rivet-Salvaging Machine*

IT costs less to let a rivet lie than to pay for the riveter's time to pick it up, but the Glenn L. Martin Company, of Baltimore, found that their cleaners were sweeping up some 60 lb. of light metal parts, principally rivets, every day, and that this represented a loss of about 60 dollars, which is about 15,000 dollars per year. Not even putting a team of boys on sorting the swept-up rivets solved the problem, as their wages were found to be greater than the value of the rivets saved.

But the tool design office produced a machine designed to do the work automatically. The first process is to pass an electro-magnet over the floor sweepings and so remove all the steel parts. Next, the rivets are put through a series of sieves, which separate the various diameters, after which the rivets travel, heads up and shanks down, along an inclined track from the feeding hopper into teeth cut in the perimeter of a big wheel. A small fixed arm can be adjusted to knock off either the round-head or the countersunk type into a bin, while the remainder go through and "feel" with their shanks for the flaring springs below, which force them off the wheel into their proper bins. The long shank rivets fall first and the shortest last.

To save re-sorting those of different head shape which were knocked off the wheel, a small machine is available to do a preliminary sorting into head shapes only, and the rivets may be put through this before going to the larger length-sorting machine. This head sorter works at twice the speed of the length sorter, and can do 100 lb. of ⅜in. rivets in eight hours. It is claimed that the expense of running these rivet sorters is small, and that of the 15,000 dollar potential annual loss due to dropped rivets, 12,000 dollars is recovered through the use of the machines. It is obvious that the principle could be applied in many industries using rivets, irrespective of their size.

When the tool design office was first presented with this problem they must have regarded it as nearly insoluble. But there is little that modern design cannot do.

* Reprinted from *Flight*

A U-Tube Manometer for Fan Testing

By G. G. McDONALD, Ph.D.

EARLY in 1937 the writer designed and had constructed from odds and ends found in the laboratory workshop the U-tube manometer diagrammatically illustrated in the accompanying Figs. 1 and 2. It was used to measure the pressures developed at various points in, and also the delivery from, a small experimental fan. The following description of the instrument may be of interest to those engaged in the testing of fans.

One limb of the manometer is a 0·4in. bore glass tube A firmly clamped to a frame B formed of 2in. by 2in. angle iron bolted vertically to a column in the laboratory. The other limb consists of a closed brass reservoir C, of 4½in. internal diameter, supported on three levelling points W, one of which, D, is an adjusting screw for setting the meniscus in A to zero when required. Close behind A and sliding in guides in B is a brass scale E having a number of fine horizontal lines S scribed lightly upon its surface. The scribed lines are spaced at exactly 1in. intervals. This scale has a travel of about 1½in. and is moved up and down by means of a finger-operated rack and pinion gear F. At the top of E is fixed a hardened steel anvil G which engages with the spindle H of a 1in. micrometer head I fixed to the top of B. Sliding stiffly on E is a holder J containing a low-power reading lens K and an electric bulb L. J is kept square with E and prevented from slipping by a coach spring M—Fig. 2. The bulb lights up E, the meniscus N, and a little sharp-ended pointer O, which is fixed inside J at the level of the centre of K, and whose function is to train K exactly on one of the lines on E. K is low enough in power to

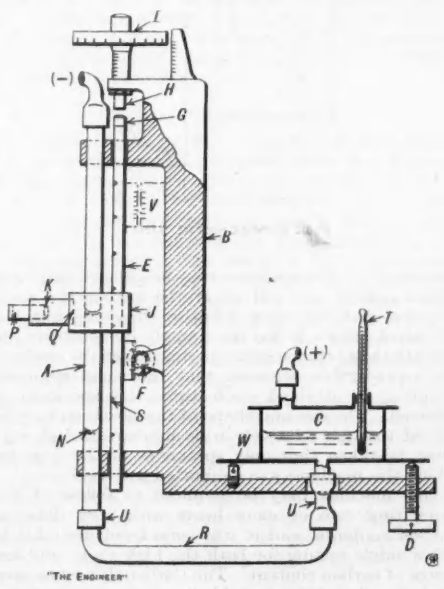


FIG. 1—ARRANGEMENT OF U-TUBE MANOMETER

allow E, N, and O to be viewed together with reasonable definition. Parallax is avoided by fitting horizontal eye and object slits, P and Q, in front of and behind, K.

In setting the manometer to zero, both limbs are opened to the atmosphere, and the meniscus is allowed to settle for a few minutes. The micrometer head is set at zero and the scale is racked up until the anvil just touches the micrometer spindle. The lens holder is moved along the scale until the pointer is in line with the zero line on the scale. The meniscus is then brought to the zero line on the scale by raising or lowering the reservoir slightly by means of the adjusting screw.

In taking a reading, C is first connected to the source of pressure, A remaining open to atmosphere, and the position of N is noted. If, to take an example, N should rise to a position between the 8in. and 9in. lines on E, J is first raised so that O is seen to coincide with the 8in. scribed line on E. H is then slacked back and followed up by G until the 8in. line, which is continuously in view through the eye-piece since

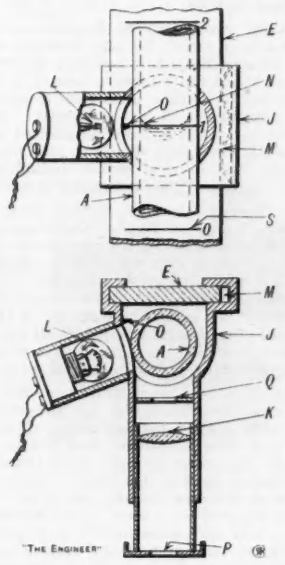


FIG. 2—READING LENS ARRANGEMENT

the latter moves with E, touches N. When G is in light contact with H and the 8in. line touches N, the micrometer reading gives the fraction of an inch, in excess of 8in., corresponding to the height of the meniscus above its zero position.

The fluid used in the manometer is alcohol, and a thermometer T is fitted to the reservoir, so that the density of the alcohol can be read from a curve. To reduce possible creeping of the zero due to hydrostatic dilatation of the normal rubber tube connection between A and C under high heads, the metal tube R is used and is connected to A and C by two short rubber connections U.

Manometric heads up to 17in. can be read with this gauge with an overall visual accuracy of about $\pm 0{\cdot}0025$in. of water column. This accuracy is ample in fan tests, for which the British Standards Specification 848—1939 requires a visual accuracy of $\pm 0{\cdot}005$in. of water column. For heads over 5in. it is proposed to fit between B and E a vernier V reading to $\pm 0{\cdot}01$in.

The instrument is of robust construction, and has proved serviceable. The glass tube is of uniformly large bore, so that errors due to capillary effects are negligible.

LINOLEUM AS A FIRE-RESISTANT.—Some instructive experiments have been conducted by the Linoleum and Floorcloth Manufacturers' Association, of Staines, Middlesex, on the fire-resisting properties of linoleum, with particular reference to its use as a covering for wooden floors in houses. In a book, with a copy of which we have been favoured, the Association illustrates photographically the results of a number of tests carried out with incendiary bombs set alight on plain wooden floors, on wooden floors treated with fireproof paint, and on wooden floors, plain or painted, covered with various thicknesses of linoleum. In the case of both the plain and the painted wooden floors a 1-kilo. bomb after burning for ten minutes is shown as having burned a hole right through the flooring to an extent sufficient to allow it to fall on the floor below. A similar test applied to the same floors covered with linoleum of the 6·700 mm. grade showed that after ten minutes the surface of the linoleum was charred but that the wood below was not burned through. Even after allowing the bomb to burn itself out—that is to say, after about thirty-five minutes—the wood underneath was charred on the surface, but not burned through. Further, the area of the fire did not increase as the bomb continued to burn, the spluttering magnesium failing to ignite the surrounding linoleum. With lesser thicknesses of linoleum the protection afforded was naturally decreased, but even with a covering of the 3·30 mm. grade, eight minutes elapsed before the wooden flooring started to crackle. The tests were carried out in the open air while a stiff breeze was blowing, that is to say, under conditions much more favourable to the spread of fire than prevail within a house.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quantities are f.o.b. steamer

Non-ferrous Metal Merchants

We have frequently referred in these columns to the situation of the metal merchants who, by the rules and regulations of the Non-Ferrous Metal Control Department of the Ministry of Supply, have been in the position of having to do their work without receiving any remuneration. They have had, in fact, to observe the official prices for copper, lead, and spelter, both as buyers and sellers, and so have been deprived of the opportunity of making any profit. For a long time negotiations have been proceeding with the Ministry of Supply in order to obtain permission to charge a small profit on their transactions. This seemed the more reasonable since the Control followed the principle enunciated by the Ministry of Supply earlier in the war that the normal channels of trade were to be observed so far as possible. Metal merchants, therefore, were supplying their old customers under the conditions just outlined. The negotiations, however, have now reached a satisfactory stage, and it is announced that the Ministry of Supply has agreed in principle to pay commissions to members of the London Metal Exchange for transactions in copper, lead, and spelter effected since the war and prior to December 18th last. Claims referring to these transactions may be forwarded as soon as possible to the Non-Ferrous Metal Control at Rugby for examination. Complete details of the scheme have not yet been arranged. As regards transactions after December 18th last, it is presumed that negotiations will be continued. During the last war merchants were allowed an authorised percentage as commission, and in some trades this policy is being pursued at the present time.

The Pig Iron Market

Business in the pig iron market has become restricted almost entirely to transactions with firms engaged upon war contracts. These appear to be for the most part engineering concerns occupied on a variety of work for the Government. The requirements of the engineering foundries have risen appreciably of late, and considerable tonnages of low-phosphoric pig iron and hematite are being taken up. Foundry grades are in poor request, and many of the furnaces have been put on to the production of basic iron. The poor demand from the light castings industry for ordinary foundry qualities has enabled this to be done without affecting consumers. A certain number of the light castings makers are being given contracts in connection with the war effort, but these are comparatively few and the hopes entertained a short time ago that the Government would be able to employ a considerable proportion of the idle plant in this industry have been disappointed. There is certainly a tightness in the low-phosphoric iron department, and in spite of efforts to increase production the demand remains in excess of output. The production of basic iron is being pressed to the utmost and large tonnages are being turned out. The call from the steel works, however, is so heavy that the domestic output falls short of requirements and considerable tonnages are being brought into the country. It is interesting to note that since the outbreak of the war prices of Northants and Derbyshire foundry irons have been increased by 21s. per ton, hematite by 15s. 6d., and basic by 18s. to 20s. 6d., according to district. There is no reason to suppose, however, that these advances have had any influence whatever upon the volume of business transacted. A large proportion of the work in hand is on Government account and is of an essential character, and for this reason consumers are much more interested in the deliveries they can obtain than in the price of the material.

Scotland and the North

Normally, preparations would be in hand for closing down the Scottish works for the annual Fair holidays. This year, however, all idea of holidays has been relinquished and there will be no cessation of work except in cases where the necessity for overhauling plant is the primary consideration. Much of the machinery has been in operation without interruption for long periods and is badly in need of attention. The consuming works will also continue in full operation and the demand for steel is not likely to show any diminution this month. With the works in full production, therefore, the output of steel remains at an almost record scale, and the whole of it passes immediately into consumption. A very complete control of the works is exercised and the steel makers have to devote their energies to the kind of production required by the Ministry of Supply. The demand for structural material of all kinds is maintained at an extraordinarily high level, and this kind of steel is passing in large tonnages to the constructional engineers and shipbuilders. The yards on the Clyde are in full operation and a large tonnage of shipbuilding is under construction and will provide an outlet for steel for a long time to come. The locomotive makers are busy and are taking up good quantities of plates, whilst the tank makers are also well employed. Naturally, under the prevailing conditions, there is a big demand for shell steel. Railway material of various kinds is being produced at the Scottish works. The sheet industry is producing at a rate only limited by the supply of sheet bars, but the works are finding it difficult to satisfy the demand. The Lancashire market is active and consumers are struggling to obtain supplies. Interest is taken in the result of the recent restrictions on the supply of steel for non-essential work, but the Lancashire consumers take the view that so much of the demand for heavy steel has been on work of national importance that it will make little difference to the activities of firms in that district. There is an insatiable demand for bars, both large and small, and particularly for reinforcing steel. The call for alloy steels for mechanised equipment is steadily expanding. On the North-West Coast the steel works continue producing at capacity, and large quantities of hoops and strip and general descriptions of steel are passing into consumption.

The Midlands and South Wales

Little comment has been heard regarding the advance in prices made by the Control of Iron and Steel (No. 10) Order. Some such move was expected, but expressions of surprise are still heard regarding the extent of the increases. Whilst so much of the production is going at once into consumption upon Government work, however, there is little time or inclination for criticism of prices. The chief concern of consumers is to obtain supplies and the price paid is a secondary consideration. It is interesting to note, however, that for certain descriptions of steel the price is now at a higher level than at any time during the 1914–1918 war, although true comparison is impossible, since a variable subsidy was paid by the Government to the steel makers during the later stages. Pressure to obtain all sizes of joists, sections, and bars is unrelaxed, and notwithstanding efforts to restrict the use of steel to war necessities the home production, plus imports, is barely sufficient to meet requirements. The programme of factory construction and extensions is proceeding at a great pace, and huge quantities of finished steel materials are being absorbed. All the constructional engineering firms are fully employed and are likely to remain so for some months. The demand for plates, also, is extremely heavy, and the amount of business in ferro-alloys and special steels has increased considerably during the past few weeks. The fears of the re-rolling industry that as a result of the loss of supplies from Belgium and Luxemburg it would have to go short of deliveries of billets and sheet bars have been allayed as a result of the substantial imports of semis from America and Empire countries. The production of small bars, sections, and strip is on a big scale, and the demand is so strong that, notwithstanding all efforts to increase outputs, there is some delay in deliveries. The increase in the export prices of small bars from £14 to £17 16s. 6d. occasioned some surprise, but, in actual practice, there has been very little export business transacted by this section of the industry for some time. In South Wales the steel works are operating at as near capacity as their supplies of raw materials permit, but the output of tinplate bars is not sufficient to meet the full requirements of the mills.

Copper and Tin

Prices in the world copper market have a strong tendency to recede. This is the result of the withdrawal of France from the war and the closing of so many markets which are in German occupation. Japan has been buying a certain amount of copper and this seems the only remaining market if Great Britain, who is obtaining most of the copper she requires from the Empire, is not counted. Russia has placed some inquiries, but there is a definite objection on the part of copper producers to sell to that country. No doubt Japanese needs are heavy, but for some weeks now their purchases in the United States have been on a restricted scale. The difference between American domestic and export quotations has contracted, and the home market price is now 10·87½c. d/d and the export 10·45c. f.a.s. A notice has been issued by the Control of Non-Ferrous Metals requesting all owners of public or private warehouses situated in Great Britain, Northern Ireland, and the Isle of Man in which virgin copper is in store to furnish a return of this metal. The return should give the fullest possible information as to the quantity, quality, brand, marks, and ownership of every lot, and should be received not later than July 22nd. . . . In the tin market some surprise has been occasioned by a statement that for the time being the American Government is not buying tin at the agreed price of 50c. Dealers have been under the impression that to accumulate 75,000 tons in a year would tax the resources of the market and would lead the United States Government to buy any tin offered. Apparently, however, the Government is satisfied that the arrangements it has made will produce the required tin in the stipulated time. It is understood that 5000 tons has been bought from the Dutch Colonies. The demand for tin for general purposes appears to be expanding, and in America the tin-plate mills are understood to be operating at 77 per cent.

Lead and Spelter

The situation in the lead market has not materially changed for some weeks, and consumers continue to receive their full requirements. A very great proportion of the manufacturers of lead products are engaged upon Government contracts and large quantities of the metal are passing into consumption. The collapse of France has naturally had an influence upon the position, since Great Britain is understood to have taken over some of the lead contracts and in consequence can devote metal to the production of exportable products. The situation in the various consuming trades is distinctly good. The cable makers appear to be working at the maximum capacity, whilst the battery makers are also fully employed. The position of the lead pipe and sheet makers is stated to be less satisfactory since the quiet times in the building trade have affected the demand from that industry. In the United States the market is firm, although business has been quiet for some time. The American Bureau of Metal Statistics gives the American deliveries for the first five months of this year as 218,819 short tons, a considerable increase upon the 193,508 tons for the corresponding period of 1939. . . . The demand for spelter has not declined from any direction, and although consumers engaged upon essential war work receive their supplies those occupied upon ordinary commercial contracts do not find it so easy to get their full requirements. Supplies are apparently reaching this country with regularity and in sufficient quantities to make the situation comfortable. There is a suggestion, however, that economy might be exercised in Government specifications for various articles which it is buying in in considerable quantities, including A.R.P. equipment.

Notes and Memoranda

Rail and Road

MOTOR-CYCLES FOR THE GOVERNMENT.—There was a very good response to a recent appeal for several thousand motor-cycles and about 500 combinations for War Office duties. The prices offered were: Maximum for 1936 model, £40; minimum, £24; maximum for 1939 model, £66; minimum, £44.

CHAUFFEURS FOR WAR WORK.—An appeal by the Minister of Labour and National Service is directed to employers of chauffeurs and chauffeur-mechanics. It is suggested that many can be released for war work in armament factories. Men of this type should readily adapt themselves to such work, especially if they take a course in a Government training centre or in a works.

BELT ROAD FOR CHUNKING.—Despite frequent aerial bombings the City of Chunking, China, is considering the spending of 10,000,000 dollars on a belt road round the city to be built over a period of three years. There are many engineering difficulties in such a scheme, for the road is to be above the highest water level on record of the two rivers on three sides of the peninsula on which Chunking is situated. Embankments at places will be 60ft. high.

AMERICAN OIL-ELECTRIC TRAINS.—The Chicago, Rock Island and Pacific Railroad has added two more streamlined, oil-electric passenger trains to its "Rocket" fleet, for service between Kansas City and Colorado Springs. The overnight service covers 629 miles in 11 h. 35 min. westbound and 11 h. eastbound. At Belleville the westbound Kansas City section joins with the Rocky Mountain "Rocket" from Chicago to form a nine-car train with 3000 H.P. oil-electric power units.

G.W.R. APPOINTMENTS.—The directors of the Great Western Railway have authorised the following appointments:—In the engineering department, Mr. H. Savage to be new works assistant, chief engineer's office, Paddington; in the stores department, Mr. H. R. Webb to be principal assistant to the stores superintendent, Swindon, *vice* Mr. F. H. Dashwood, who is retiring; Mr. C. F. Faith to be assistant to the stores superintendent, Swindon, *vice* Mr. H. R. Webb; and Mr. A. G. Roberts to be assistant to the stores superintendent, Swindon, *vice* Mr. F. T. Willis, who is retiring.

HOLIDAYS WITH PAY.—To enable trade board industries and the road haulage industry, which have a statutory obligation to allow specified holidays, to comply with the Ministry of Labour's direction to postpone or so to rearrange holidays that there shall be no interference with continuity of production or with the flow of transport, the Minister has made an Order. It prolongs until March 31st next year the period within which a holiday with pay must be granted. About 1,500,000 persons are engaged in industries in which wages and other working conditions are determined by trade boards and the road haulage industry normally employs about 160,000 workpeople.

GUN WELDERS FOR AUTOMOBILE BODIES.—To speed assembly and reduce the number of rejects, seventeen electronically controlled gun welders have replaced former methods to assemble automobile bodies in some plants in America. In one modern radiator and grill assembly department each of six gun welders joins twenty separate parts at 150 places in less than a minute. It is said that because the gun-welded bonds are stronger, only half as many welds are used. An electronic control developed by the Westinghouse Company is claimed to prevent burned spots, to reduce rejected assemblies to a minimum and to require no maintenance. Spot, projection, flame and arc welding were all previously used. Conventional spot welding was particularly troublesome, producing burned spots and poor bonds. Much work had to be repaired and at times burns were so bad that the parts were scrapped. The gun welders were designed by the Progressive Welding Company.

Air and Water

UNITED STATES LINES.—The United States Lines' ships "Manhattan" and "Washington," which maintained a regular service between New York, Plymouth, Southampton, Havre and Hamburg before the war, are to be operated from New York to San Francisco, beginning with the sailing of the "Washington" from New York on July 26th.

AMERICAN SHIPBUILDING.—Returns published by the American Bureau of Shipping show that there were building in American shipyards on June 1st, 1940, a total of 295 vessels of 1,516,185 gross tons. At April 1st, 1939, the total was 165 vessels of 678,750 tons and at February, 1938, 91 vessels of 390,990 tons. The figures therefore show a considerable expansion of the industry.

AMERICAN AIRCRAFT ORDER.—A report from America states that the Vega Aeroplane Company, a subsidiary of the Lockheed Aircraft Corporation, has been given a 30,000,000 dollar contract to build a new design of bomber for Great Britain. The machines, known as Lockheed "Vega 37s," are larger and faster than the Lockheed "Hudsons," already supplied to the Royal Air Force.

BRITISH NAVAL LOSSES.—H.M.S. "Escort," a destroyer of the "Eclipse" class, is announced as lost in the western Mediterranean. She was hit by a torpedo and subsequently foundered while in tow. Two rating ost their lives. "Escort," a 36-knot vessel, had a displacement of 1375 tons and a normal complement of 145. She carried four 4·7in. guns, six smaller guns, and eight 21in. torpedo tubes. She was completed in 1934 by Scotts' Shipbuilding and Engineering Company, Ltd., of Greenock. H.M. Submarine "Shark" is considerably overdue and must be presumed lost. "Shark" was one of the smaller submarines, of 760 tons displacement. Her normal complement was forty, and she was armed with six 21in. torpedo tubes and one 3in. gun. She was built at Chatham Dockyard, where she was completed in 1934.

THE I.N.A. LIBRARY AND DENNY MEMORIAL.—The Institution of Naval Architects' Library has now been completed by the erection of the Memorial to the late Sir Archibald Denny, Bart., LL.D. (Honorary Vice-President). The Library is situated at the offices of the Institution at No. 10, Upper Belgrave Street, London, S.W.1 and is open to members during the usual office hours.

MERCANTILE LOSSES DUE TO ENEMY ACTION.—During the week ended Sunday, July 7th, inclusive, the total British tonnage lost was 75,883, consisting of thirteen merchant ships. Three Allied and six neutral vessels, of tonnage 9635 and 28,669 respectively, were also lost by enemy action in this period. Out of the 100 million tons of shipping convoyed since the outbreak of war, less than one-quarter of 1 per cent.—47 ships in all—have been lost through enemy action.

BRITISH TRANSATLANTIC AIR SERVICE.—Representatives of British Overseas Airways have announced in New York that Transatlantic flights between the British Isles and New York by way of Montreal and Botwood will begin within a few weeks. The aircraft will carry both mails and passengers. It will be recalled that this route was that on which experimental flights for a regular service were first started by Imperial Airways and Pan-American Airways in July, 1937.

CANADIAN-BUILT SUBMARINE CHASERS.—Three of ten submarine chasers being built in Canada for the British Admiralty have been completed ahead of schedule, according to an announcement by the Department of Munitions Supply in Ottawa. The chasers are known as "corvettes" and will also be used for escort work. These vessels are understood to be identical with the so-called "whale-catcher" type, of which fifty-six were ordered for the Royal Navy before the war.

CANADIAN NAVAL CONSTRUCTION.—As part of a 10 million pound two-year programme to build 100 ships for the Royal Canadian Navy, eighty-two vessels are on the stocks at sixteen Canadian shipyards. Three general types of vessels are being constructed, but their classification and dates of commissioning must remain secret. In following the specifications of the British Admiralty a problem has been to find allowable substitutes for some of the indicated material. A new line of electrical fittings, for example, has been developed with the help of Canadian manufacturers, and steel plate specifications have been altered to suit manufacturing plants. Empire materials are being used throughout.

GERMAN SCRAP METAL.—An Air Ministry announcement states that a number of aluminium-coloured metal rods, 3ft. 9½in. long by ¾in. diameter, have been picked up after German air raids on this country. At one end is a rectangular metal plate, 7½in. by 6in., held in place by a large washer and shackle (ring), and at the other a ½in. fine-thread stud with plain washer. The rods are used for holding incendiary bombs in the containers of enemy aircraft and are dropped with the bombs. The finding of a number of these rods has been reported to the Air Ministry, but as they possess no technical value, finders are advised to take them to their local authorities for disposal under the scrap metal salvage scheme and thus let German metal assist in the war against Germany.

ENEMY AIRCRAFT LANDINGS.—Although the authorities have asked that obstructions should be placed on all ground which might prove suitable for enemy aircraft attempting to land, there are still many areas in which no precautions have been taken. In case there should be doubt as to the size of landing ground necessary, the Junkers 52 aircraft, a machine which Germany has used for landing troops in other countries, requires a minimum landing space of about 300 yards. To take-off this type of machine requires about 400 to 450 yards run, but the risk of landing without being able to take off might be taken in order to land troops. It is suggested that anyone knowing of suitable landing grounds which are unobstructed should get into touch with his local authority.

Miscellanea

THE LATE COLONEL SIR GEORGE WILLIS.—We regret to have to record the death of Colonel Sir George Henry Willis, C.I.E., M.V.O., late R.E., at the age of sixty-four. He went to the R.M.A., Woolwich, and was commissioned in the Royal Engineers at the age of twenty. He will be chiefly remembered for establishing the printing of Government promissory notes in India. He helped to form the Institute of Engineers (India) and held for a year the position of President of the Council.

CENSUS OF AMERICAN ENGINEERS.—The American Society of Civil Engineers announces that the engineering and architectural professions are preparing for national defence by taking a census of 115,000 engineers and architects skilled in the design and supervision of all types of construction needed in case of national emergency. The census is being undertaken by the Society jointly with the American Institute of Architects, and many American professional organisations are co-operating.

GAS DETECTOR ANALYSER.—For continuously indicating the purity or concentration of gas within the casing of hydrogen-cooled electrical machines the General Electric Company of America has designed a detector analyser on the hot wire Wheatstone bridge principle. One arm of the balancing circuit consists of an electric heater element which is energised at a constant rate so that the temperature it assumes is an inverse function of the thermal conductivity of the gas surrounding it. It is declared that if a hot wire element is placed axially in a metal tube whose internal diameter is less than 1 cm. and the surfaces of both wire and tube are polished so as to reflect heat radiations, at least 99 per cent. of the heat loss will be by conduction, the negligible remainder being by radiation and convection. Thus temperature change is a measure of the percentage of one gas in the sample mixture flowing through the heater block cell, which contains two dual spiral filaments.

OPTICAL ELECTRO-MAGNETS.—Two types of electromagnets designed to extract iron splinters from the eye were used with success by the Swedish Red Cross during the Russo-Finnish war. The larger type weighs 140 kilos. and is said to be the strongest optical magnet in the world, although the power consumption is only 1·1 kW. The weight of the smaller magnet is about 6 kilos. and the power consumption 110 watts. Requiring current at a tension of 6 volts, it can be fed by an ordinary accumulator.

THE ENGINEERS' GUILD.—The services which the Engineers' Guild will be able to render to the engineering profession will be more needed than ever in the conditions that are bound to prevail in the post-war period, says the secretary. It is felt therefore that members will wish the Guild to be in a position to resume full activities as soon as practicable, and to secure this they are requested, if they have not already done so, to pay their subscriptions. The amount of subscriptions overdue at May 31st was approximately £150.

WIRED GLASS FOR WAR-TIME BUILDING.—In a technical memorandum issued by the Ministry of Supply, Passive Air Defence Branch, it is stated that while wired glass does not afford full insurance against splintering, it is very much less liable than plain glass to splinter under the effects of an explosion in the vicinity. The memorandum continues:—"It is therefore advised that, where glass is essential, wired glass should be used in the glazing of vital shops, &c., in new factory buildings, and for replacement of damaged glass in existing factories."

PLASTICS EXPORT GROUP.—British plastics manufacturers have formed an Export Group as part of the Board of Trade export drive. They are issuing a catalogue in four languages illustrating hundreds of different articles made from British plastics. No effort is to be spared to capture markets hitherto held by Germany. The British plastics industry has grown remarkably in the last ten years. In addition to hundreds of articles for the export trade, it is now providing the fighting services with a great variety of supplies ranging from safety razors to air frames.

COMMUNAL FEEDING FOR MUNITION WORKERS.—So great has been the demand for the Industrial Welfare Society's booklet "Canteens in Industry" that a third edition has now been published. This edition appears at a particularly opportune moment when the provision of communal feeding facilities has been brought to the fore by the work of the new Factory and Welfare Advisory Board of the Ministry of Labour. Many books have been compiled recently on menus and feeding generally, but few deal with the vital preliminary work of planning and equipping premises or the problems of management once the canteen is established. The Industrial Welfare Society's booklet, which is based on the experience of hundreds of firms of all types and sizes throughout the country, supplies this information. With the appearance of a new edition, opportunity has been taken to go through the whole text most carefully, and many additions have been made. Special attention has been given to the problems raised by rationing, by the need to provide meals for both day and night shifts, and by the difficulties of giving quick service of hot meals and refreshments in very large and scattered plants. Copies of the booklet may be obtained from the secretary of the Society, 14, Hobart Place, Westminster, S.W.1, price 1s., or 1s. 2d. post free.

PERSONAL AND BUSINESS ANNOUNCEMENTS

STANDARD TELEPHONES AND CABLES, Ltd., has opened a branch office at Temple Courts, Temple Row, Birmingham, 2, which will be under the management of its local representative, Mr. J. Gilmour.

S. WOLF AND CO., Ltd., Hanger Lane, London, W.5, announce that following negotiations with Acton Electric Tools, Ltd., they have taken over the sales and service of Rotax universal and high-frequency electric tools.

MR. J. RANDLE, M. Eng., has resigned his position as engine works manager of Lobnitz and Co., Ltd., engineers and shipbuilders, Renfrew, to take up as from August 1st, 1940, the duties of works manager of Kryn and Lahy, Ltd., engineers and steel founders, Letchworth.

CROMPTON PARKINSON, Ltd., has given up its offices at Bush House, London, which it has occupied for the last twelve years. From July 15th its new address will be Electra House, Victoria Embankment, W.C.2. Its associate company, the Atlas Sprinkler Company, Ltd., is also transferring from Bush House to Electra House.

MR. T. SARSON, assistant managing director of the Stanton Ironworks Company, Ltd., has retired from the service of the company, after an association extending over sixty years. Mr. Sarson started his career with the Holwell Iron Company, Ltd., and rose to be its managing director. When that company was acquired by the Stanton Company in 1918, Mr. Sarson became assistant managing director, a position he held until his retirement last month. The vacancy caused by Mr. Sarson's retirement has been filled by the appointment of Mr. P. H. Wilson to assistant managing director (technical), and Mr. A. Watson who will act as assistant managing director (commercial).

CATALOGUES

WESTINGHOUSE BRAKE AND SIGNAL COMPANY, Ltd., Pew Hill House, Chippenham, Wilts.—Descriptive pamphlet No. 11 L on the "Noregy" and "Westat" constant-voltage rectifier systems.

MULTICORE SOLDERS, Ltd., Bush House, London, W.C.2.—A booklet entitled "Solders and Soldering" dealing with the composition and uses of "Multicore" solder—a self-fluxing wire solder having three cores.

CROFTS (ENGINEERS), Ltd., Bradford.—A new 544-page, quick-reference catalogue of the wide range of standard power transmission appliances made by the firm. In addition to detailed specifications of the various appliances, the book contains a large amount of useful data and information.